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1955

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IN THIS ISSUE:

CYSTICERCUS BOVIS (BEEF MEASLES) IN KENYA

FORAGE LEGUMES FOR MEDIUM ALTITUDES IN KENYA

RUN-OFF AND SOIL EROSION TESTS, MPWAPWA, CENTRAL TANGANYIKA

THE POSSIBILITIES OF TREE-BREEDING AND OF TREE SEED ORCHARDS IN EAST AFRICA

SPECIES OF TILAPIA IN EAST AFRICAN DAMS, WITH A KEY FOR THEIR IDENTIFICATION

INDEX TO VOLUME XX, 1954-55

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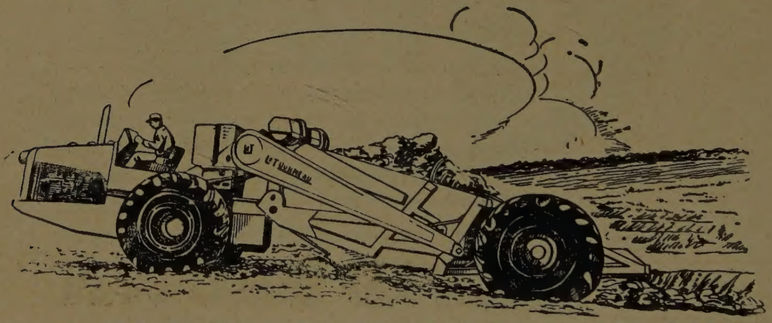

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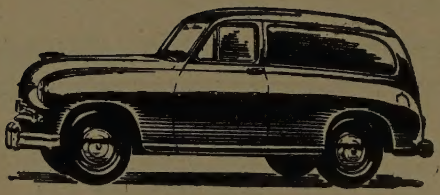

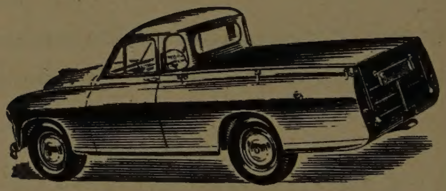

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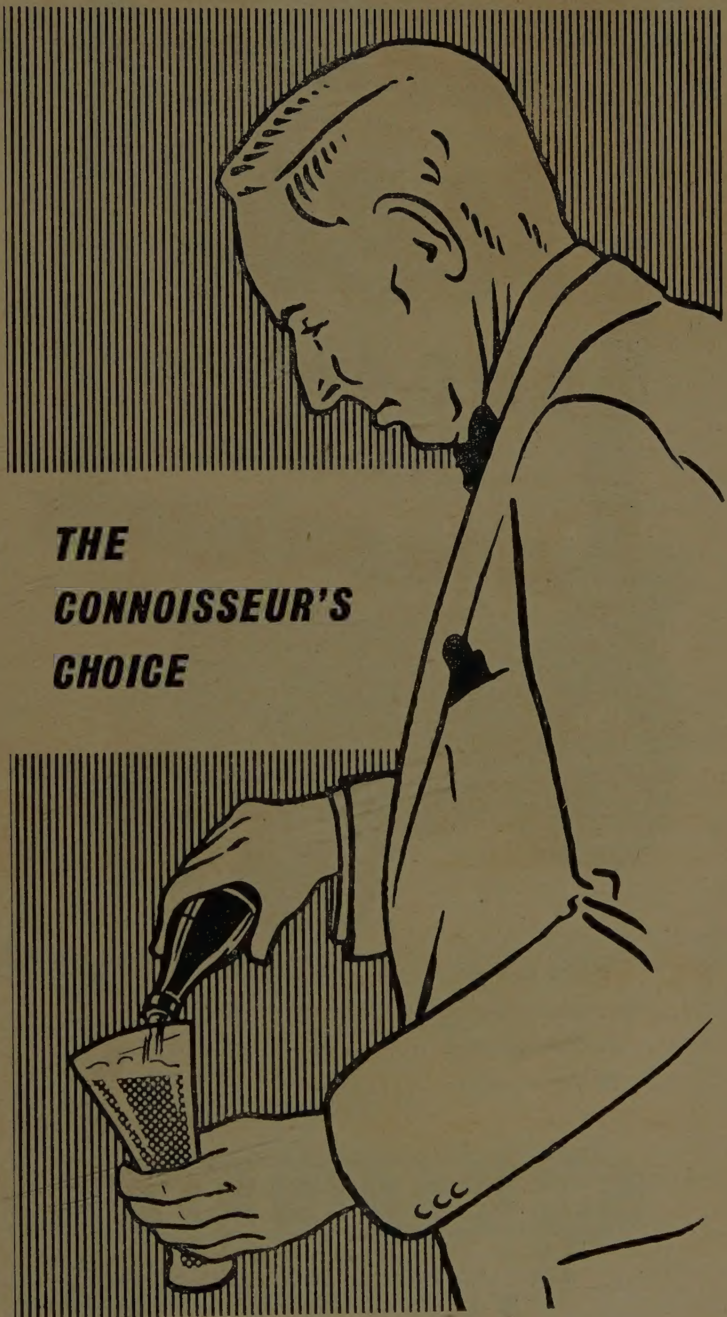

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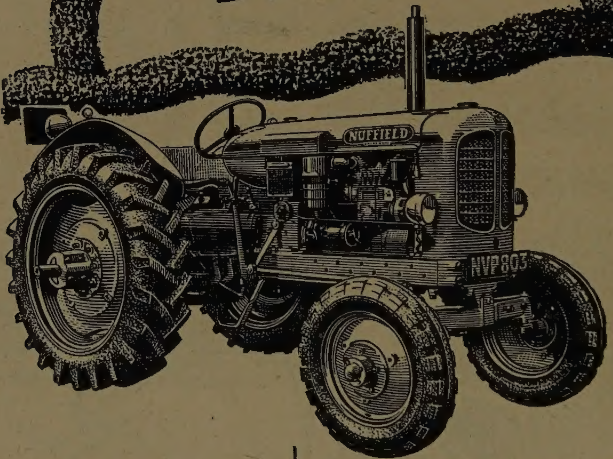

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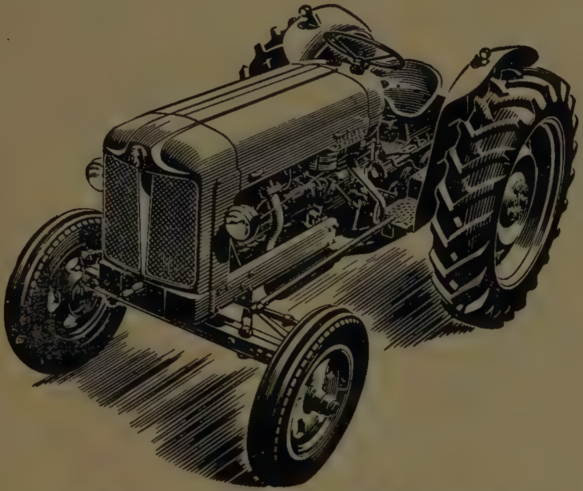

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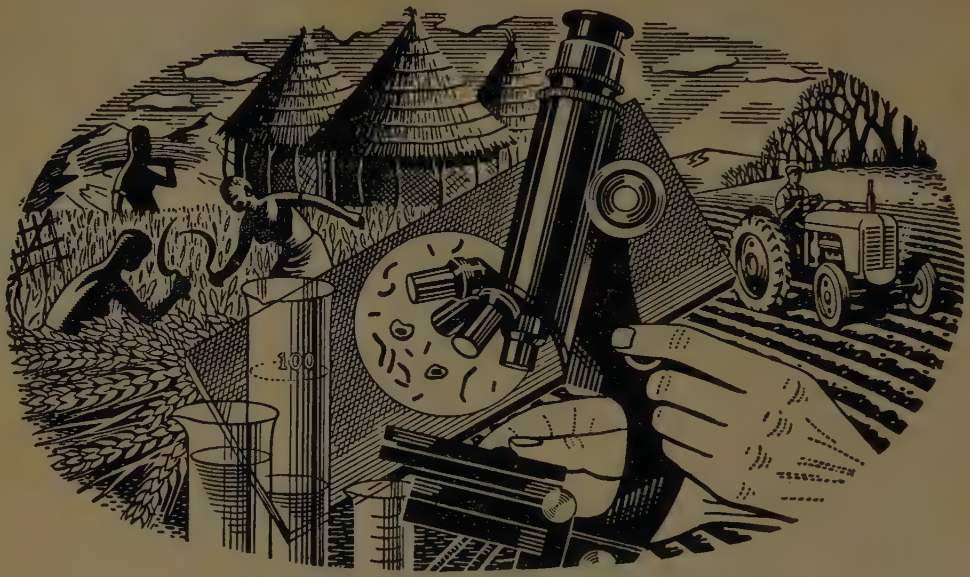

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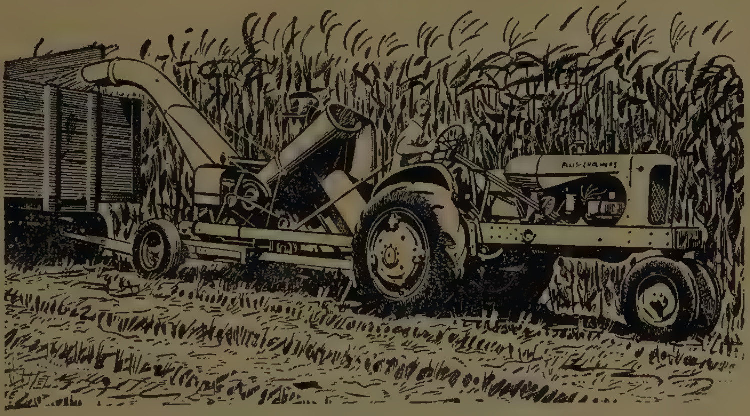

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CONTENTS

	PAGE
Inter-African Bureau for Epizootic Diseases, Muguga, Kenya	213
Reviews	215, 267
Cysticercus bovis (Beef Measles) in Kenya	216
Removal of Excess Fluorine from Drinking-water for Stock	220
Forage Legumes for Medium Altitudes in Kenya	221
The Treatment of Loose Smut of Barley in Kenya	225
Run-off and Soil Erosion Tests, Mpwapwa, Central Tanganyika	228
Tree Growth on a Seasonally Dry Swamp in Eastern Uganda	232
E.A. Milk Records of Leading Cows—June to December, 1954	236
Nutritive Value of Green *Indigofera subulata* Herbage	240
The Possibilities of Tree-breeding and of Tree Seed Orchards in East Africa	241
Nutritive Values of Locally Prepared Cotton-seed and Linseed Cakes	245
Land Usage in Semi-arid Parts of Tanganyika	247
Nutritive Value of Coffee Hulls	254
Species of Tilapia in East African Dams, with a Key for their Identification	256
A Study of Crop Production in Relation to Rainfall Reliability	263
Plant Ecology as an Aid to Colonial Development	268
Living Virus Vaccine in Rabies Control	269

INDEX TO ADVERTISERS

	PAGE
African Explosives & Chemical Industries (E.A.), Ltd.	XIV
African Mercantile Co., Ltd.	XI
Barclays Bank D.C.O.	IV
Blake-Mackay Engineering Co. (Africa), Ltd.	XV
Bovill, Matheson & Co., Ltd.	IX
Caltex (Africa), Ltd.	COVER PAGE 3
Dunlop Tyres	COVER PAGE 4
East African Breweries, Ltd.	VII
East African Railways and Harbours	I
Gailey & Roberts, Ltd.	VIII
Hughes, Ltd.	XIII
International Harvester Co. of E.A., Ltd.	XII
Macgregor-Oates Motors, Ltd.	VI
National Bank of India, Ltd.	V
Ndurumo, Ltd.	X
R. E. Smith, McCrae, Johnson & Co., Ltd.	II
Shell Company of East Africa, Ltd.	XVI
Smith, Mackenzie & Co., Ltd.	COVER PAGE 2
Standard Bank of South Africa, Ltd.	V
Twentsche Overseas Trading Co., Ltd.	III
United Africa Company (Kenya), Ltd.	XI
Wigglesworth & Co. (Africa) Ltd.	IV

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INTER-AFRICAN BUREAU FOR EPIZOOTIC DISEASES, MUGUGA, KENYA

This Bureau has been established at Muguga for three full years but, except in the comparatively small section which veterinarians occupy within the full circle of scientific endeavour in Africa, its origin and functions are virtually unknown.

The Bureau is an inter-African organization set up under the ægis of the Commission for Technical Co-operation in Africa South of the Sahara, known as C.C.T.A. from the initial letters of the title in the French language.

The C.C.T.A. itself is a permanent inter-government statutory body set up by the Governments of Belgium, France, Federation of Rhodesia and Nyasaland, Portugal, the Union of South Africa and the United Kingdom in 1952, for the purpose of stimulating co-operation between these governments in the technical advancement of their territories in Africa South of the Sahara. The Commission has a permanent Secretariat in London financed by the six governments mentioned above and headed by a Secretary General, who at present is a French national.

This Commission has set up inter-African organizations situated in many parts of Africa which deal with such varied subjects as labour relations, trypanosomiasis, epizootic diseases, soil science and rural economy, pedology, statistics, human nutrition, social sciences, housing research, etc.

The origin of the Bureau for Epizootic Diseases is set in the proceedings of the International Conference on Rinderpest held in Nairobi in 1948. At this conference it was recommended that a Rinderpest Bureau be established to collect, and distribute, all the information available on rinderpest. This recommendation was accepted by the governments represented at this conference and it was decided that the scope of the Bureau be enlarged to incorporate all the serious diseases which afflict farm animals in Africa, hence the name epizootic, which is readily understood when it is remembered that it is the equivalent of "epidemic" which relates to diseases of mankind only.

The Bureau was to be established at Muguga in order that it could have the advantage of close association with a large modern fully staffed veterinary research Institute, and complete library facilities on veterinary and allied subjects.

In accordance with precedent, the host government provided the capital funds. The United Kingdom gave a grant of £7,000 and this was added to that already provided by the United Kingdom for the establishment of E.A.A.F.R.O. and E.A.V.R..O. at Muguga and the offices and quarters of the Bureau were included in the general layout of this Research Station.

The project has turned out to be a very happy inspiration and the Bureau, while quite independent financially, both originally and in recurrent expenditure, enjoys many advantages, social, scientific and administrative which would not otherwise be available so readily in offices in Nairobi.

The Staff in the formative years consisted only of the Director, a veterinarian with long service in the Colonial Veterinary Service, and a Secretary/Translator. The work of the Bureau has been appreciated by the governments concerned to the extent that the staff is being doubled in 1955.

A Council of Management governs the activities of the Bureau. It consists of veterinarians of senior status in the service of the governments of the six participating countries. The Council meets once a year at Muguga or in the capital city of one of the governments. The Chairman for the first three years is a French national, the head of the Overseas Veterinary Service of France whose office is in Paris.

The *Inter-African Bureau for Epizootic Diseases,* contracted to IBED for convenience, is, therefore, a statutory international government organization located in Kenya, but not part of the government service of Kenya, the

East Africa High Commission, or even the United Kingdom, except in so far as these territories contribute to the finances of the Bureau. In fact, in an annual budget of £10,000 per annum which the Bureau now costs, the contributions from Kenya, Uganda and Tanganyika and Zanzibar amount to approximately 10 per cent of the total. At present the annual budget is provided by the six participating governments in the following proportions:—

	Per cent
Belgium	14
France	22
Portugal	10
Federation of Rhodesia and Nyasaland	4
Union of South Africa	10
United Kingdom	40

The Functions of the Bureau can be summarized in a single sentence: to collect, collate and disseminate any information of value to veterinarians in Africa on the diseases of economic farm animals which are present, may be present or are likely to be introduced, on this continent, and to maintain liaison between veterinarians in Africa.

All territories in Africa below Lat. 20° North collaborate by sending information regularly to the Bureau in accordance with an agreed upon system.

They supply the latest information on outbreaks of animal diseases, the measures being used to combat them, research being carried out in their veterinary laboratories, the field use of vaccines and other agents for prophylactic and curative purposes. The Bureau is kept up to date, on new techniques, new legislation for the control of disease and changes in senior personnel.

A Bibliography is being documented according to an approved scientific system from references extracted from over 100 scientific periodicals and over 50 annual reports of veterinary departments in Africa and elsewhere, regularly read by the staff and abstracted. Reports of conferences, symposia, committees, etc., are received from a great many sources.

The collection of all this information into the archives of the Bureau would have little positive value other than for library purposes. It is necessary, therefore, to distribute it in collated form as widely and as quickly as possible to the individuals who will find it useful. This is effected by means of a weekly information leaflet, a quarterly bulletin, a quarterly summary and replies to individual inquiries.

The working languages of the Bureau, as indeed its parent body, the C.C.T.A., and all its inter-African units, are French and English. Every item of information to be distributed from the Bureau has, after preparation for dissemination to be translated into both languages and is then issued simultaneously in the two texts sometimes under one cover or in other cases separately.

The weekly *information leaflets* give up-to-date summaries of conferences of veterinary interest, on reports of the work of specialized agencies like U.N.O. and F.A.O., information on new techniques, and news on fresh outbreaks of disease.

The *Bulletin of Epizootic Diseases of Africa* is published quarterly and Vol. III begins in 1955. It contain original articles on all aspects of the control of disease, research, education, maps showing the geographical distribution of disease, and contains abstracts of reports and the scientific literature and reviews on animal diseases of topical interest.

A *Quarterly Summary on Vital Statistics* gives in a standard form under a system of codes, the disease situation in every territory in Africa in the previous quarter of the year, and the latest change in the legislation affecting animal diseases.

Liaison.—The second important function is liaison. Not only does the Bureau staff visit several territories in Africa each year to consult and discuss local aspects of their work and give information on similar problems elsewhere, but many visitors come to the Bureau from other countries to seek information from the collection now established. The Director has attended conferences all over Africa and many parts of Europe, acts as liaison officer between regions at meetings of Regional Committees, and has discussed the subject of international cooperation in veterinary science with appropriate ministries of many territories.

Visits of veterinary scientists from one country to another, contacts between institutes, and individuals dealing with the same specific subject, and the introduction of standard practices in techniques are facilitated by the Bureau and many exchange visits of personnel have been initiated and assisted.

In addition, it is within the competence of the Bureau to arrange conferences, symposia, and training courses. In 1955 a course in the latest laboratory techniques and field control of rabies, lasting about three weeks, has been arranged to take place in Africa to train veterinarians whose special duties are connected with rabies. The several teachers at this course are world authorities on various aspects of this disease.

Thus, briefly the origin, the functions and the implementation of these functions have been described not for purposes of publicity but to draw attention to the part which veterinarians in Africa are playing in schemes for more rapid progress in eradication of the animal diseases which are of such importance to the stockowner and the national economy of most countries in Africa.

W. G. BEATON.

REVIEW

Management Records. The Maintenance of Histories of Forest Management Units in the British Commonwealth. Compiled by N. V. Brasnett. I.F.I. Paper No. 39, 1954: 1–82. Imperial Forestry Institute, Oxford. Price six shillings.

A knowledge of the past history of a forest area is of great value not only for estimating its future potentialities but also for adding to general knowledge of silvicultural techniques under prevailing conditions. There are great differences in the method of recording the information and of the type of information recorded. This largely varies with the state of development of the country and the intensity of the forest management. The first step to procure a general improvement is to collect and collate information on existing procedures for a comparative and critical study. This the Fifth British Commonwealth Forestry Conference strongly urged at its meeting in 1947. Such a collation of information is a long and tedious work and involves world-wide correspondence with forest departments usually overworked and understaffed. Some idea of the scope of the work will be seen from the fact that brief descriptions have been given of the general methods used in each of fifty territories. As forest management intensifies and regular working plans are prepared, the amount of information and its method of collection naturally tends to become more and more codified, but the history of the forest area before this stage is reached is of the greatest importance. Most of the units of the Commonwealth have not yet got to the Working Plan Stage.

Mr. Brasnett is to be congratulated on this very readable work which is a normally very unreadable subject, and particularly on his useful conclusions which are generalizations of wide applicability.

A.L.G.

CYSTICERCUS BOVIS (BEEF MEASLES) IN KENYA

By Alfred Ginsberg, Department of Veterinary Services, Kenya

(*Received for publication on 22nd November, 1954*)

Cysticercus bovis, commonly known as "measles" in beef, was already known in biblical times as a condition encountered in the skeletal muscles of cattle. The etiology of this parasite, however, its life cycle, its relationship to *Tænia saginata*—the beef tapeworm—and its pathogenicity to man were not discovered until the end of the 18th century. For the first time, in 1767, Linné described *Tænia saginata* as a tapeworm living exclusively in the intestine of man. A hundred years later Küchenmeister was able to establish the relationship between *Cysticercus bovis* and *Tænia saginata*. The popular name "measles" is of unknown origin and must have come into being during the middle ages to explain a condition resembling a spotty eruption, especially so if the cysts are numerous. The choice of such a term was unfortunately not a happy one and during the centuries that followed the name caused more than one feud. Children suffering from measles or *Rubeola*, a bacterial and not a parasitic disease in human beings, were accused of having infected the poor ox which was condemned for "measles" when sold for slaughter to the butcher in town. But, however misleading the English popular name may be, the French, "Ladrerie" is more so as it was used in the olden days to describe leprosy. The Poles named it "blackheads" and the Germans "pimples". The scientific term is *Cysticercus bovis* derived from the Greek, *Kystis*—bladder, and *Kerkos*—tail, *bovis* denoting the animal in which this bladderworm is living.

For a considerable period the opinion prevailed that this parasitic disease was only encountered in the Orient or Africa, because Jews and Mohammedans alike were known to suffer from *Tænia saginata*. Thus, any case of tapeworm found in Europe was simply ascribed to direct or even indirect contact with someone from the Orient or Africa. This grave misconception was finally clarified by Professor Peroncito of Turin who supplied ample scientific evidence that a beef tapeworm will develop only if man consumes *Cysticercus bovis*—"measles". This discovery changed the approach, and strict inspection in public abattoirs of all carcasses of cattle was demanded forthwith. The Berlin municipal slaughterhouse was the first to respond, and after introducing additional methods of inspection was able to declare that 300 carcasses were found to be infested with *Cysticercus bovis* during the first year on record. Other abattoirs adopted Berlin's routine measures of inspection and soon it became apparent that *Cysticercus bovis* is to be found all over the world, but that its incidence is dependent upon the standard of hygiene and sanitation of the country concerned. Once this was established, eradication methods were devised and introduced. The results obtained were impressive, and especially so in Central Europe where the incidence was greatly reduced within a comparatively short time.

With the visible improvement of the situation as well as scientific discoveries concerning the sterilization of meat, some concessions were granted. *Cysticercus*-infected carcasses were divided into two categories, those showing a small and those showing a large number of cysts. The former, following the removal of all visible cysts, had first to be sterilized either by cooking or freezing before being passed as fit for human consumption. This concession met with strong resentment from the general public. The consumer immediately pointed out that having paid normal market price for a pound of beef he was entitled to receive meat which is derived from healthy animals and not from beasts infested with parasites. The specialists in food hygiene welcomed a procedure which guaranteed safety to the consumer, but raised objections for æsthetic reasons and demanded that such carcasses be marked.

To satisfy both public and hygienist, Germany introduced the "Freibank", or "free-counter", which is a butcher's shop run under veterinary supervision and attached to each municipal abattoir. This shop, a non-profit-making concern, sells at reduced prices meat of inferior quality, or meat which has been sterilized because of *Cysticercus* or tuberculosis. To prevent speculation not more than 5 lb. of meat are sold to any individual customer, and butchers, hotels, and restaurants are not permitted to purchase there. In Britain, the Ministry of Food laid it down in 1952 that carcasses with localized cysticercosis should be released for human consumption without further restrictions, provided they had been sterilized by freezing.

The life cycle of *Tænia saginata*—the beef tapeworm—begins when man consumes raw or under-cooked beef containing viable cysts of *Cysticercus bovis*. Once these parasites reach the human stomach their protective capsule is digested and the head or parent (scolex) of the future tapeworm is released. Having gained its freedom the head attaches itself by means of four very strong suckers to the mucous membrane of the small intestine and growth commences. Segment after segment is added to the head and neck until about 1,600 give the beef tapeworm its renowned length of anything up to 30 feet. Each segment is an independent unit containing both male and female sexual organs. Once these segments become fully mature they detach themselves from the rest and are then excreted, from four to ten segments are passed daily, and the number of eggs deposited may reach as many as 500,000.

It is about ten weeks after the consumption of measly beef that the mature segments start to leave the human intestines, a process which gives rise to an unpleasant itch and a sensation of moisture in the anal region. It is quite a common occurrence for an infested person to find segments in his underwear or bed. The eggs (ova) are fairly resistant and if deposited in damp grassland or water may remain active for seventeen weeks or more. Once the eggs are swallowed by cattle grazing on contaminated pasture the larval cycle of *Cysticercus bovis*—bladderworm of the ox—begins.

The larva, freed by the stomach juice from its surrounding capsule, migrates through the intestinal wall of the infected cattle, heading towards predilected muscles of the body. The odd egg may be arrested on its way and thus remain in some unusual place, as for instance the kidneys, liver, or brain. Once firmly established, growth of the larval cyst begins and after about 18 weeks full development is achieved. At the same time, however, a tendency towards degeneration is evident, and one year after infection has taken place the body of the affected animal has usually freed itself from the disease—provided no reinfection has occurred. It is probably for this reason that calves show a much higher percentage of *Cysticercus* infections than fully grown cattle; although acquired immunity cannot be ruled out, more scientific proof is still required to support this assumption.

The cyst or "measle" is a round or oval bladder lying embedded in the muscles. It consists of an external envelope, formed by the reaction of the tissues of the host, i.e. the infected cattle, and an internal envelope produced by the parasite itself. The latter encloses the head of the future tapeworm which appears as a glistening white spot through the cyst wall. The size of the cyst varies according to the stage of development, and may range from that of a pin's head to a pea. Besides these translucent cysts there are some with thicker walls containing smaller *Cysticerci*. In sucking calves cysts appear as round or oval, semi-transparent, greyish vesicles varying in size from a millet seed to a pea.

Until July, 1953, it was the practice in Kenya abattoirs to pass as fit for human consumption carcasses showing not more than six cysts in the course of routine examination. Carcasses containing seven or more cysts were condemned outright. There were obvious objections to this practice, since it is self-evident that a carcass revealing as many as six cysts during the course of examination may well contain further cysts elsewhere in the deeper muscles. These concealed cysts were being passed on to the consumer without prior sterilization. On the other hand, the destruction of carcasses containing seven or more cysts, but in which no tendency towards generalization was revealed, constituted a waste of valuable protein available for human food.

When the Department of Veterinary Services assumed responsibility for meat inspection at the Kenya Meat Commission plant at Athi River, the availability of adequate refrigeration made it possible to revise previous practices. Pending the introduction of a statutory Code of Judgment for meat inspection it was agreed, after discussions with the medical authorities, that every carcass revealing less than 20 cysts in the course of routine examination would be subjected to sterilization by freezing for a period of not less than 14 days. Those carcasses containing less than seven cysts were then released after a further examination; those with from seven to 20 cysts are not released for general sale to the public, but are available for manufacturing purposes or as contract meat to large employers of African labour.

Table I.—Cysticercosis in Cattle and Calves Encountered During Twelve Months at the Meat Works of the Kenya Meat Commission at Athi River

Origin of Slaughtered Animals	Total number of Infested Farms	Number of Slaughtered Animals	Action Taken During Meat Inspection			
			Cattle Retained for Freezing (1–6 cysts)	Cattle Retained for Freezing and degraded (7–20 cysts)	Cattle Condemned (over 20 cysts)	Total number of Infested Cattle
European Farms	406 (38%)	28,125	1,337 (4·70%)	2,935 (10·43%)	617 (2·10%)	4,889 (17·23%)
African Reserve		7,856	1,047 (13·32%)	1,411 (17·19%)	726 (9·24%)	3,184 (39·75%)

Origin of Slaughtered Animals	Total number of Infested Farms	Number of Slaughtered Animals	Action Taken During Meat Inspection			
			Calves Retained for Freezing (1–6 cysts)	Calves Retained for Freezing and degraded (7–20 cysts)	Calves Condemned (over 20 cysts)	Total number of Infested Cattle
European Farms		1,117			259 (23·18%)	259 (23·18%)
African Reserve		77			43 (55·84%)	43 (55·84%)

This adjustment has been mutually advantageous in that the consumer of Kenya Meat Commission beef, whoever he may be, has the assurance that no carcass containing cysts will leave the plant with viable parasites which might endanger his health. The livestock producer in his turn has been saved substantial losses arising from the total condemnation of carcasses which contained more than six cysts; 28 per cent of the carcasses which would otherwise have been condemned were released as contract beef after freezing, and 1,807,490 lb. of beef, which would otherwise have been destroyed, became available for consumption during the first year of operation under the new system.

These measures, however, apply to only one meat-producing centre. In the African areas routine inspection of beef carcasses cannot yet be introduced on a scale likely to affect the overall incidence of cysticercosis, and the African labourer therefore remains a potential source of infection for European-produced livestock.

Nevertheless, it has already been demonstrated by a number of European farmers in Kenya that effective hygiene and sanitation on the farms can very substantially reduce the loss attributable to *C. bovis* infection, a loss which, even with the current sterilization by freezing, still amounts to at least £30,000 a year. Records maintained over a 12-month period at Athi River show that 23 per cent of all cattle admitted to the abattoir were infected with *Cysticercus*, and that 38 per cent of all European producers have supplied cattle so infested. Some producers have forwarded cattle in which more than 50 per cent of adult stock were found to be infected, and there have been cases where the infection rate in calves has been higher than 60 per cent.

Such losses can be very substantially reduced by appropriate measures on the farm and every livestock producer submitting infected cattle now receives, as a routine, a report from the Medical Department. It may be some time before a full-scale campaign on a country-wide basis, including the African areas, can be introduced in Kenya, but in the meantime every farmer can do much to reduce the risks of infection among his own cattle, and the observance of the following ten points will be found to be helpful:—

(1) Provide latrines for your native labour and insist on their use. Punish persons responsible for the contamination of grazing land.

(2) Discover the human carriers of *Tænia saginata* on your farm and have them treated.

(3) Offer a reward for the production of tapeworms, in order to assist in the identification of carriers.

(4) Make a habit of giving your native labour compulsory treatment at least once a year. Treat all newcomers.

(5) Make sure that evacuated tapeworms are burnt or otherwise destroyed.

(6) Prevent cattle from grazing around your native labour lines and places where human evacuation is likely to be deposited.

(7) Remember that hand-reared calves are easily infected if an attendant is a carrier of *Tænia saginata.*

(8) Keep cattle away from pools which may have been polluted by human excreta.

(9) Do not spread contents of cesspools either on grazing land or as manure for the cultivation of green fodder.

(10) Fence your paddocks and if possible take measures to prevent the entry of trespassers.

REMOVAL OF EXCESS FLUORINE FROM DRINKING WATER FOR STOCK

By G. W. Walker, Veterinary Research Laboratory, Mpwapwa, Tanganyika

(*Received for publication on 24th January,* 1955)

In recent years the problem of fluorosis in cattle has been receiving considerable attention and the reviews of Mitchell and Edman [1] and Schmidt and Rand [2] cover much of the work which has been done in assessing the toxicity of fluorine to domestic animals.

Walker and Milne [3], from data gathered in the Northern Province of Tanganyika, have shown that for cattle in that area the critical toxic level of fluorine in the drinking-water is between 18 and 25 p.p.m. At 18 p.p.m. the animals have the usual teeth lesions associated with fluorosis including a certain amount of abnormal wear of the teeth in older animals, but this seems to have little or no effect on the well-being of the animal, whereas at 25 p.p.m. skeletal abnormalities occur.

In Tanganyika many of the natural waters, both streams and boreholes, have a fluorine content in excess of 18 p.p.m. and hence it was considered desirable to attempt to devise a simple economic method of lowering the fluorine content to a safe level.

The solubility of calcium fluoride is of the order of 17 p.p.m. at normal temperatures and it had been observed that all the water samples with a very high fluorine content which had been examined showed a high carbonate alkalinity and an extremely low calcium content. The possibility of adding a soluble calcium compound to these waters in order to co-precipitate the bulk of the fluorine with the carbonate was, therefore, investigated. Lime was found to have little effect, but calcium salts such as the chloride and sulphate were effective. It was found that by this means it was possible to reduce the fluorine content to approximately 13 p.p.m.; a value which is safe for stock. From considerations of cost and availability, together with ease of application, calcium chloride is the salt of choice.

It is necessary to determine the optimum amount of calcium chloride required for each individual water, this quantity in general varying more with the carbonate content of the water than with its fluorine content. An additional advantage of the method is that the pH of the water is simultaneously reduced.

The following results will serve as an example of its application. A borehole water was analysed with the following results:—

Carbonate alkalinity ..	53 mg./litre
Bicarbonate alkalinity ..	580 mg./litre
Fluorine	28 p.p.m.
pH	8.8

By the addition of varying amounts of calcium chloride to this water it was found that the optimum amount was 0.54 grm. of calcium chloride per litre. This, after mixing and sedimentation gave a water with a fluorine content of 13 p.p.m. and a pH of 7.4.

The cost of the process for treating this water would be Sh. 1.85 per one thousand gallons based on a quoted cost price for calcium chloride of Sh. 145 per 600-lb. drum (f.o.r. Dar es Salaam) of 70-72 per cent calcium chloride.

ACKNOWLEDGMENT

I am grateful to the Director of Veterinary Services, Tanganyika, for permission to publish this note.

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FORAGE LEGUMES FOR MEDIUM ALTITUDES IN KENYA

By R. Strange, Grassland Research Station, Kitale, Department of Agriculture, Kenya

(*Received for publication on* 4*th December*, 1954)

This paper is a revision of one presented at the 6th International Grassland Congress, in which the writer attempted to survey some of the main forage legume requirements in the mixed farming areas at medium altitudes (roughly 5,000–8,000 ft.) of the Kenya Highlands. The present revised lists of species are based on more recent experience gained from small nursery plots and preliminary grazing trials at Kitale, combined with observations in other parts of the Highlands. Although they must be regarded as tentative at this stage, it is thought that these suggestions may be of interest to farmers and research workers in parts of the tropics where conditions are comparable.

Kitale lies 1° N. of the Equator, north-east from Lake Victoria. The altitude is 6,200 feet. The mean mainfall is 46 in., falling mainly between April and October, with a drought period (hot season) from December to March. The average day temperature is 81° F. in the hot season, and 74° F. during the rains. The soil is a friable sandy loam of medium fertility, varying from grey to red, with a pH generally between 5 and 6.

LEGUMES FOR GRAZING LEYS

The term grazing leys, as used here, is meant to include all general purpose sown pastures which will withstand intensive grazing.

It remains to be seen whether any advantage will be gained from using mixtures of legumes in future, and this aspect will be investigated once the individual species have been selected and brought into use.

In temperate climates the ideal form for intensive grazing appears to be one in which the plants are procumbent or stoloniferous and will root freely from the nodes, making a well-knit sward with the grasses. Only a small number of our legumes possess this form, however, and more erect types such as lucerne might well be used, providing they possess the other desirable qualities such as productivity, persistence and palatability, and are suitably managed.

In the earlier paper referred to, species for grazing leys were listed in groups according to their growth form, but further experience suggests that a simpler grouping is preferable. The species for grazing leys are, therefore, now given in two groups, namely annuals and perennials.

Annuals

As in some parts of Australia and southern U.S.A., annuals may prove useful for some of our lower rainfall areas where drought is generally too severe for the reliable persistence of perennials. They might also prove valuable in other parts where soil conditions, e.g. impeded drainage or very low fertility, are unfavourable for suitable perennials.

Where the leguminous constituent of a ley is an annual, it must be able to produce sufficient viable seed each year, in spite of close grazing, to ensure that its population is maintained during the life of the ley.

The following species appear to be promising:—

Medicago denticulata, burr clover.

Trifolium rueppellianum (= *subrotundum*), large red flowered form.

Trifolium rueppellianum (= *subrotundum*), small purple flowered form.

Trifolium subterraneum, subterranean clover.

Antopetitia abyssinica, this may require more careful management than the others to ensure full establishment.

A number of other annuals are also under observation.

Perennials

It is probably safe to assume that where suitable species can be found, perennials are preferable to annuals as the main leguminous constituents of grazing leys of two or more seasons' duration. The perennial, once established, will generally have the advantages of a stronger root system, earlier production at the start of the season, and greater reliability as a more persistent component of the pasture. The following species have shown encouraging growth in current observations and will, with others, provide a basis for further work in various parts of the Highlands. It should be made clear that no order of priority is intended in this or any of the other lists given here:—

Trifolium semipilosum var. *glabrescens*, Kenya wild white clover.

Trifolium semipilosum var. *kilimanjaricum*, Kenya wild white clover.

Trifolium cheranganiense, Cherangani clover.

Medicago sativa, lucerne.

Teramnus repens.

Teramnus labialis.

Alysicarpus glumaceus, Alyce clover.

Stylosanthes gracilis.

Indigofera subulata (= *retroflexa*).

Glycine javanica.

Lotononis bainesii.

Clitoria ternatea (for black cotton soils).

PERENNIAL LEGUMES FOR FODDER LEYS

For the purpose of this paper it is convenient to clarify species for fodder leys separately from grazing leys, since certain vigorous forms, while probably able to withstand periodic cutting, may die out if grazed intensively. Such legumes might therefore prove most useful for combination with grasses in fodder leys, in which they will provide a large bulk of silage material during the flush season, followed by one grazing during the middle or late dry weather.

It should be remembered, however, that for practical purposes there can be no hard and fast division between the so-called "grazing leys" and the "fodder leys". Thus, a tall growing mixture which might be classified as a fodder ley could be used primarily for grazing if so required, given suitable and careful control. Furthermore, it is possible that in certain areas some of the same grasses or legumes will be used for both types of ley, the main difference between the two types being in management and utilization rather than in the species.

With these qualifications in mind, the following twiners are suggested as being worth trial in perennial fodder mixtures. These are showing some promise in current trials at Kitale:—

Dolichos sp., ex Kilima Kiu.

Dolichos falcatus.

Dolichos sp. nr. *lablab*.

Disappointing results have so far been obtained from *Pueraria phaseoloides* and *Centrosema pubescens* which are popular in other parts of the tropics. This is probably on account of the rather cooler climate here.

The grasses used in these fodder type leys will be vigorous perennials, erect, and satisfactory for periodic cutting, but generally not suitable for intensive grazing. The habit is illustrated by species such as *Pennisetum purpureum*, *Panicum maximum*, *Sorghum* spp., *Setaria sphacelata* and *Setaria splendida*.

Of the non-twining perennials which are well suited to hay or silage production, special mention must be made of lucerne. When the problems of cultivation have been solved and suitable strains selected, there is some prospect of lucerne becoming increasingly used in the Kenya Highlands in temporary leys. Depending on the mixtures used, these might be regarded as roughly intermediate between the fodder type of ley and the grazing ley, being equally useful for either purpose if managed accordingly.

Where these leys are sown with the object of hay or silage production, the lucerne should be mixed with a compatible grass, either broadcast or in various row arrangements, or it may be grown in a pure stand, preferably in rows to facilitate cultivation.

Such a mixture based on lucerne or a similar legume may have the following advantages over the type of fodder ley described earlier, in which the herbage is of a somewhat coarser nature.

Firstly, it will probably be more satisfactory for the production of hay. The grass used in mixtures is likely to be a fine-stemmed, non-aggressive species which will be comparatively easy to handle and cure.

Secondly, the "intermediate" type of ley based on lucerne and similar legumes may prove more reliable to establish from seed than will the "fodder" type in which seed production and poor germination has been a difficult problem with many of the species tried so far. Reliable establishment from seed will be a necessary prerequisite if any grass is to be combined successfully with lucerne in pastures of this kind. A ley which can be established easily from seed will have much to recommend it to farmers, compared with one in which vegetative propagation is necessary, even though species such as *Pennisetum purpureum* are easy to establish from cuttings or root divisions. For this reason the intermediate type of fodder ley may become popular when satisfactory combinations have been found.

These remarks apply to other species having a form similar to lucerne, which might be sown mainly for fodder conservation. One such possibility is *Indigofera subulata* (=*retroflexa*). This is doing well on the red volcanic soils of the Nairobi-Thika district.

ANNUAL LEGUMES FOR FODDER PRODUCTION

For economic reasons, perennial fodder mixtures are preferable to annuals if their yields are comparable in quantity and quality. Unless or until such mixtures can be evolved, however, annuals will continue to play an important part in mixed farming areas for the production of hay and silage. At present oats are most commonly used for hay, and maize for silage, generally in a pure stand. As in temperate regions, the use of a legume in mixtures with these annuals might do much to improve the quality, and is generally desirable. The following are some suggestions:—

For use in mixtures with tall growing cereals such as maize or sorghums:—

Stizolobium deeringianum, Velvet Bean.
Phaseolus lunatus, Lima Bean.

For use in hay or silage mixtures with the shorter growing cereals such as oats, or for growing in a pure stand:—

Lupinus spp., sweet edible Lupins.
Dolichos lablab, Fiwi Bean.
Crotalaria intermedia.
Vicia spp., Vetches.
Trifolium rueppellianum.
Melilotis alba, Sweet Clover.
Medicago denticulata, Burr Clover.
Vigna sinensis, Cowpea.

The more succulent and fleshy of these such as *Lupinus* spp. and *Dolichos lablab* will be more difficult to cure for hay, and are more satisfactory for silage.

LEGUMES FOR EARLY PRODUCTION IN LEY ESTABLISHMENT

When a ley is established by direct seeding, there is usually a gap of some weeks immediately after sowing and before the first grazing, during which weed growth is liabe to become a problem. In order to fill this gap, companion species can often be sown with the ley. These may consist of a cereal such as oats, or an oats-legume mixture, or solely legumes which will give early grazing and then be replaced by the more permanent species in the second season.

Grazing is thought to be generally preferable to hay-making or ensiling as a means of using the companion crop if soil conditions permit. The cover can thereby be removed at an earlier stage and the mechanical action of the grazing animal is believed to be beneficial to the establishment of the young seedlings beneath.

The following are species which appear to be worth further trial for this purpose:—

Lupinus spp., Sweet Edible Lupins.
Dolichos lablab, Fiwi Bean (Annual).
Ornithopus sativus, Serradella.
Melilotis alba, Sweet Clover.

LEGUMES FOR UNDERSOWING IN ANNUAL CASH CROPS TO GIVE IMPROVED GRAZING AFTER HARVEST

The sowing of legumes under maize or other cereals will tend to improve the overall quality of crop residues for dry season grazing after harvest. In the case of wheat, grazing of legumes in the stubbles could do much to overcome the difficult problem of straw disposal after combine harvesting. Even if not grazed, the ploughing under of well-nodulated legumes should assist the decomposition of the straw and help to make good any nitrogen deficiency in the following crop. A number of species have been tried under maize, and encouraging results have been obtained so far from:—

Stizolobium deeringianum, Velvet Bean.
Dolichos lablab, Fiwi Beans.

The latter has been used successfully in the Nakuru area but has not done so well at Kitale.

As yet little work has been done on undersowing wheat. In one small observation, however, the growth of *Crotalaria intermedia* was quite encouraging The following are probably worth trial for this purpose:—

Ornithopus sativus, Serradella (at high high altitudes, over 7,000 ft.).
Melilotis alba, Sweet Clover.
Melilotis officinalis.
Medicago denticulata, Burr Clover.
Trifolium rueppellianum.

Twining legumes should be used with caution in straw crops as there is a greater danger that they will interfere with harvesting operations.

Legumes for Catch-crop Grazing and Green Manuring

In a ley farming system, where a certain proportion of the grassland is ploughed before the end of each growing season, there is a place for rapidly growing legumes which can be sown on the upturned sod. Such plants, while helping to prepare the ground for the following crop, might also provide some useful dry weather grazing if palatable species are sown. At present oats are sometimes used in this way, but it is felt that the addition of a well-nodulating legume, or a pure stand of legumes, may be an improvement.

For this purpose rapidity of growth is an essential requirement, besides bulky production and efficient nodulation. There are of course a number of possibilities, and the following are suggested as being amongst those which are worth consideration:—

For green manure only—

Lupinus spp., Non-palatable bitter lupins.

Crotalaria incana (has low palatability).

For grazing—sown alone, or in a muxture with a companion species such as oats:—

Lupinus spp., sweet edible lupins.

Medicago denticulata, Burr Clover.

Ornithopus sativus, Serradella.

Trifolium rueppellianum.

Legumes for Soil Conservation

As demonstrated with Kudzu in U.S.A., the sowing of a suitable legume can be valuable for the protection of eroded slopes, and for gully stabilization. The use of a non-palatable species may have particular advantages in areas of communal grazing or where there is little control of stock movement. The following are species which might be worth further trial:—

Rhynchosia minima, a vigorous twiner; hardy and of low palatability.

Glycine javanica, palatable.

Dolichos sp. *ex Kilima Kiu*, palatable.

The fixation of atmospheric nitrogen by the legume should be mentioned because, although nodules may often be found on roots, it appears that these are frequently inefficient in these parts of Africa. The study of this is therefore of importance, as without effective nitrogen fixation the emphasis on legumes becomes somewhat pointless. In Kenya, attention is being given to this aspect of research, and seed inoculation with a proved inoculant (where it exists) is generally regarded as essential.

In conclusion, this paper has been written in the belief that a survey of farmers' requirements can assist towards a clearer appreciation of present problems, and will help to focus attention where it is most urgently needed. As work continues amendments will be made to the lists of species and a process of elimination will tend towards simplification and a reduction in the numbers suggested. At the same time knowledge of the most satisfactory mixtures and techniques to suit local variations in soil and climate will become more precise.

Finally, the need for simplicity should always be kept in mind in a country such as Kenya where ley farming is just beginning, and where the organized marketing and production of herbage seeds barely exists. Although in the present early stage of research a large number of species must necessarily be tested, the aim will be to use as few as possible in practice, compatible with efficient farming. Each species which is brought into commercial production will therefore be made to serve as many different requirements as possible.

SUMMARY

The uses of legumes in some of the more important aspects of mixed farming are discussed as follows:—

(1) Legumes for grazing leys.

(2) Perennial legumes for fodder leys.

(3) Annual legumes for fodder production.

(4) Legumes for early production in ley establishment.

(5) Legumes for undersowing in annual cash crops to give improved grazing after harvest.

(6) Legumes for catch-crop grazing and green manuring.

(7) Legumes for soil conservation.

Lists of species are suggested for these different purposes. Some of these at present undergoing trial in parts of Kenya Colony should fulfil requirements from altitudes of about 5,000 to 8,000 feet.

THE TREATMENT OF LOOSE SMUT OF BARLEY IN KENYA

By A. D. S. Duff, Plant Breeding Station, Njoro, and J. A. Gilmour, Egerton Agricultural College, Department of Agriculture, Kenya

(*Received for publication on* 24*th December,* 1954)

It has become evident in recent years in Kenya that the incidence of Loose Smut of barley (*Ustilago nuda*) is increasing both in severity and distribution. In fact, some very valuable varieties such as Glacier may cease to be grown on account of increasing economic loss.

The control of Loose Smut presents unusual problems in that the chlamydospore responsible for the infection of the new individual plant enters the developing seed of the previous crop and there remains dormant until the grain is sown in the following season. No visible diagnostic symptoms are present until heading time, when the entire reproductive apparatus appears as a mass of black spores borne on the rachis. Destruction of the head is complete and not a single grain can be harvested from a smut-infected plant.

As the fungal spores are windblown, spread can be considerable throughout the crop, and the fact that only a percentage of the plants are infected in one year is due, not to a paucity of spores, but because entry into the developing grain is possible only during the short flowering period. Nevertheless, if infected seed is sown year after year, the percentage of infection increases steadily and rapidly.

Glacier is a very valuable barley in Kenya but is very liable to attack by the smut fungus and, until this year, no stocks of that variety were known to be even moderately smut-free. For the last four years at Egerton College, the disease built up in intensity from an initially insignificant infection to such an extent that disease sampling in the 1953 crop showed over 15 per cent smutted heads. Glacier was abandoned as a farm crop for this reason. However, it was decided to obtain, if possible, a disease-free stock for multiplication and maintenance by the application of suitable treatments. As this was the primary object, no plots were sown with the untreated seed in 1954, but it was almost impossible to find a smut-free plant in the volunteer crop which followed the 1953 harvest. For practical purposes, infection approached 100 per cent.

Since the fungal mycelium is embedded in the internal tissues of the embryo, any treatment, to be effective, must kill the fungus without harming the delicate embryo. Until recently, the only method known was the Hot Water Treatment; but the chemical *tetra-chloro para benzoquinone,* under the trade name "Spergon" is now being used in America. The chemical is, however, far from being ideal as the germination capacity of the seed treated with it does suffer.

The object of this work was to test the relative values of a standard Hot Water Treatment and this chemical and to demonstrate that it is practicable to reduce the incidence of Loose Smut of barley on a field scale to a level where its significance is small in any one crop in any one year. It was also hoped that a completely disease-free stock could, in time, be bulked up.

HOT WATER TREATMENT

In the Hot Water Treatment [1] the object is to raise the temperature of the grain to a level where the fungus is killed but the viability of the grain embryo is unharmed. The temperature limits are fine, but the treatment is possible under careful supervision.

There are many standard treatments and the following was used:—

(*a*) The grain is presoaked in cold water for four hours, the bags being turned to ensure complete penetration of the water.

(*b*) The grain is then plunged into hot water and held at a temperature of 121°F. for five minutes.

(*c*) The heated grain is transferred to a second hot bath and held at 127°F. for ten minutes.

(*d*) The grain is spread out in thin layers and allowed to dry.

Provided that the seeds are properly dried after treatment, they may be stored for several weeks without significant deterioration, but it is recommended that they be sown as soon as possible after drying.

The apparatus used was simply a double jacket container heated by a primus stove, a thermometer being inserted in the centre of the grain bag. The temperature fell as the cold grain was placed in the hot bath but further hot water was added to adjust the temperature. Once the temperature was adjusted to the correct degree, little difficulty was experienced in maintaining it without undue fluctuation.

Sufficient grain was treated in this manner to sow 1½ acres at 60 lb. per acre.

Damage to Germination Capacity

For practical purposes, no damage is done to the germination capacity of the treated grain provided that the temperature is not allowed to exceed the permitted maximum:—

	Germination Capacity Per cent
CONTROL—Untreated seeds (2,000) Random Sampling	97
TREATED SEEDS—(2,000) Random Sampling	95
Loss in Germination Capacity	2

"SPERGON" TREATMENT

"Spergon" is a bright yellow powder, insoluble in water and presently unobtainable in Kenya. It is difficult to obtain a suspension in water, and stirring at intervals is necessary. A detergent, added to the water, aided in producing a suspension.

The method [2] involves soaking the grain in a 0.2 per cent suspension of the chemical for 48 hours. Thereafter, the seed is spread out to dry in thin layers. The method possesses the the distinct advantage of simplicity, but there is a severe drawback in that the long exposure in the water suspension tends to cause some rotting, and the seeds on drying appear brown and unhealthy. Notwithstanding their appearance and the damage entailed, a large percentage of the fungus is killed and in the field a good stand was obtained. Sufficient seed was treated to sow 2 acres at 60 lb. per acre.

Damage to Germination Capacity

	Germination Capacity Per cent
CONTROL—Untreated seeds (2,000)	97
TREATED SEEDS—(2,000) Random Sampling	47
Loss in Germination Capacity	50

FIELD RESULTS

The treated seeds were sown in two portions of a field at a seeding rate of 60 lb. per acre. 1.99 acres were planted with the "Spergon"-treated seeds and 1.53 acres with the hot water-treated seeds. In both cases, and in spite of the greatly reduced germination of the "Spergon"-treated seeds, a good initial stand was obtained. The field was later badly attacked by the barley bulb fly, *Hylemyia arambourgi,* but a good recovery was made as new tillers were produced. On harvesting, the crops yielded as follows:—

"Spergon" treated over 1.99 acres, 8½ bags/acre.

Hot water treated over 1.53 acres, 8½ bags/acre.

From the time that the plants were first coming to head in early August until all were past this stage of growth in September, counts were made at 5–6-day intervals on the incidence of smut, and all smutted plants were removed. In this connexion, it must be remembered that since the object was the production of a disease-free stock, smutted plants had to be removed before the spore sacs burst.

Twenty-seven samples, each of 100 plants, were counted on each occasion and at the end of the heading period, the percentage of smutted plants was computed.

	Per cent
"Spergon" treated	2.44
Hot water treated	0.56

The actual totals of smutted plants removed were:—

"Spergon" treated	2,847
Hot water treated ..	470

DISCUSSION

We have demonstrated that a comparatively disease-free stock of a smut-susceptible barley can be obtained from a heavily infected crop in one year and that it can be accomplished on a field scale with very simple apparatus. Further treatment of the harvested seed will, we hope, reduce the smut incidence still further. However, no matter how carefully the rogueing is carried out, a few spore sacs will burst and spread the disease before they can be removed.

The hot water treatment is undoubtedly superior to the "Spergon" treatment as a control but suffers by comparison in the difficulty of application. In spite of the great loss in the germination capacity of "Spergon"-soaked seeds and the higher incidence of smut thereafter, the method does offer a very simple means of reducing smut in a crop to within economical bounds. No drop in yield over the acreage occurred despite the damage to the germination capacity of the "Spergon"-treated seeds and the poorer initial stand was compensated by extra tillering.

Although "Spergon" is unobtainable in Kenya at the present time, due presumably to dollar restrictions, we are trying to obtain chemicals of a similar nature from Britain. Tests will be carried out on both the percentages of the chemicals used and the length of soak in an effort to reduce the loss of germination.

We also believe that a simpler hot water treatment for the bulk treatment of grain will be effective. It is hoped to show that a lower and constant temperature for a longer period will be equally suitable in Kenya. A temperature of 116.6 F. for two hours has been used in Scandinavian countries. Preliminary trials on a laboratory scale have already been carried out and show promise.

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RUN-OFF AND SOIL EROSION TESTS, MPWAPWA, CENTRAL TANGANYIKA

By H. J. van Rensburg, Department of Veterinary Science and Animal Husbandry, Tanganyika

(Received for publication on 30*th November,* 1954)

The disastrous effects of excessive erosion due to poor and incorrect farming practices have been stressed over a very long period by numerous workers interested in this subject. Staples recorded the results from a run-off and soil erosion experiment carried out at Mpwapwa in Central Tanganyika in the 1933, 1935 and 1938 annual reports of the Department of Veterinary Science and Animal Husbandry. The experimental plots were laid out near the Mpwapwa Veterinary Laboratory on red sandy loam soil typical of the area and are situated on a uniform 6.6 per cent slope.

Five plots are 1/80th acre each (6 ft. by 90¾ ft.) and the sixth is half that length but of equal width. The run-off water and eroded soil are caught in concrete tanks built flush with the surface of the soil at the bottom end of each plot. The volume of run-off was determined by measuring the depth of water in the tanks regularly during the rainy season and by removing, drying and weighing the soil in each tank at the end of the rainy season.

The average annual rainfall is 26 in. with practically all of it falling between December and April. The distribution is most erratic and, even within this period, there frequently occur lengthy spells of drought which affect crops and pasture adversely. Torrential downpours with 3 in, or more in about an hour are frequently experienced and cause havoc on bare trampled fan slopes and unprotected fields.

Some of the most impressive results given by Staples in the annual reports mentioned are:—

The extremely high rate of run-off which may take place from heavy storms, namely 81.3 per cent from a bare non-cultivated plot compared with 70.1 per cent from a plot planted to bulrush millet and 25.2 per cent from a grass-covered plot, even before the grass was firmly established.

On the plot that was half the length of the others, there was a large decrease in loss of soil per acre, namely 22.78 tons compared with 58.85 tons from the bare non-cultivated and 40.35 tons from a plot planted to bulrush millet.

The data emphasize the serious effects which may result from overgrazing and the danger of the usual methods of farming. The importance of adopting suitable systems of cultivation and the effectiveness of a pasture cover for the prevention of excessive run-off and erosion was emphatically emphasized in the 1933 and subsequent annual reports. It was pointed out that although the erosion figures were highest on bare non-cultivated, followed by bare-flat-cultivated land, even when cropped with the usual methods of flat cultivation, both run-off and erosion are extremely serious, especially in an area where moisture is the chief limiting factor in crop yields and where soil fertility is generally low.

MODIFICATIONS OF TREATMENTS

On 21st December, 1946, when readings were resumed the plots were subjected to the following treatments:—

No. 1.—Entire plot cultivated and planted, on the flat, to grain Sorghum.

No. 2.—Entire plot left under grass cover, mainly *Cynodon plectostachyum* (Star grass).

No. 3.—Top half cultivated and planted, on the flat, to grain Sorghum, lower half planted to Star grass.

No. 4.—Entire plot cultivated and planted, on the flat, to grain Sorghum.

No. 5.—Entire plot under grass cover, mainly *Cenchrus ciliaris* (African foxtail).

No. 6.—Top half cultivated and planted, on the flat, to grain Sorghum; lower half left under grass cover, mainly *Cenchrus ciliaris.*

OBSERVATIONS

It was most noticeable that, as the duration of cultivation increased the crop yields deteriorated, while during the past two droughts years the Sorghum plants were barely 12 in. high and did not produce any seeds. The same variety, planted on fields where continuous cropping had not been carried out for so long and where thorough cultivation with ridge-planting for optimum water conservation was practised, yielded 1,279 lb. and other varieties up to 1,806 lb. grain per acre.

Soil erosion, particularly on the cultivated plots, was very severe and it was evident that the bulk of the damage usually occurs on a relatively small number of days when heavy and concentrated downpours are experienced. The frequency of these vary from two or three to about twelve times per season. The texture of the soil that washes off the entirely cultivated plots is generally coarse with a high proportion of large loose sand grains, while that washed off the plots which are entirely or partly covered by grass is of very fine texture with a high percentage organic matter.

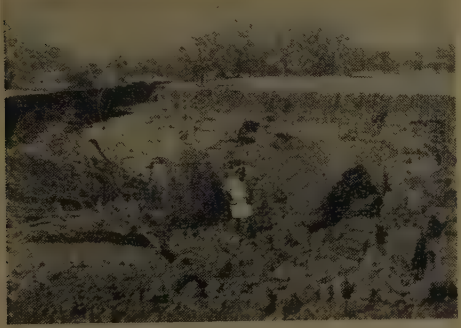

Fig. 1—Erosion near Gulwe in the Mpwapwa district, most of which occurred in one season due to uncontrolled flood-water from bare and unprotected land.

The height of the soil surface in the grass-covered plot is constant throughout, though on the cultivated plots more than 12 in. of soil along the top and central parts of the plots have been eroded away and much of it is deposited at the bottom ends of the plots, where, due to the way in which the wall was built, the soil does not easily enter the tanks. No account has been taken in the figures given for the past eight seasons of the enormous quantity of soil deposited at the lower ends of various plots where on some occasions it had accumulated to such an extent that it had to be scraped away from the sides of the walls to prevent water from flowing over the top instead of entering the tanks. At the end of the 1953–54 rainy season, however, the soil accumulated at the bottom ends of the plots was removed and weighed and is tabulated separately.

At the beginning of the 1950–51 rainy season, and since that date, plot No. 5, which until then had been under grass, was cultivated except for two grass belts each two yards wide which were left; one situated one-third of the length of the plot from the top and the other one-third from the bottom. The extent to which soil was held up by these two narrow grass belts was most remarkable while the run-off was also reduced to a considerable extent. The rate of erosion, however, was still relatively high though it was obvious that most of the damage occurred in the bottom portion of the plot where there was no protection from grass. It seems desirable therefore to have a further modification where one grass belt would be placed at the bottom of the plot and the other one half way.

In two storms on the 8th and 12th January, 1954, when 2.75 in. and 1.49 in. respectively were recorded, the percentage run-off was recorded, and is given in Table I:—

TABLE I

	Percentage run-off of rain which fell on the two days quoted.	*Percentage run-off of the whole 1953-54 season's rainfall.*
Plot entirely cultivated ..	42.0	8.8
Cultivated plot with narrow grass belts across the slope	32.5	6.8
Plot half of which cultivated and half of which grass-covered	32.0	6.6
Plot entirely grass-covered	23.5	4.9

TABLE II

PERCENTAGE RUN-OFF FOR EIGHT SEASONS

	Plot entirely cultivated.	*Cultivated plot with narrow grass belts across the slope. (4 seasons.)*	*Plot half of which cultivated and half of which grass-covered.*	*Plot entirely grass-covered.*
1946-47 ..	9.03	—	3.88	1.20
1947-48 ..	16.40	—	10.40	3.40
1948-49 ..	21.82	—	19.22	7.27
1949-50 ..	12.75	—	13.14	4.70
1950-51 ..	26.68	19.05	15.42	5.28
1951-52 ..	28.94	10.04	9.03	6.53
1953-54 ..	13.32	11.78	6.94	3.88
1953-54 ..	25.51	21.22	14.34	7.24
Average ..	19.31	15.52	11.55	4.94

Table III

Erosion in Tons of Soil Lost per Acre per Annum

	Plot entirely cultivated.	Cultivated plot with narrow grass belts across the slope. (4 seasons.)	Plot half of which cultivated and half of which grass-covered.	Plot entirely grass-covered.
1946-47 ..	11.20	—	2.28	0.38
1947-48 ..	8.70	—	1.28	0.16
1948-49 ..	26.78	—	1.10	0.31
1949-50 ..	5.05	—	0.33	0.10
1950-51 ..	39.66	4.68	1.36	0.56
1951-52 ..	52.44	18.41	1.08	0.40
1952-53 ..	3.75	1.84	0.55	0.16
1953-54 ..	29.63	22.56	2.09	0.26
Average ..	22.15	11.87	1.26	0.29
Soil washed to the bottom of the plots but prevented by the wall from entering the tanks ..	12.71	8.52	2.50	Nil

Relationship to Work in other Countries

The figures given in Tables II and III, on the whole follow the same trend as figures obtained in the United States of America, Canada, South Africa and elsewhere. Dr. Hugh H. Bennett in an article, "The Tools of Flood Control" published in *Grass*, the United States Department of Agricuture Year Book 1948 states:—

> "Flood control begins where the rains fall and run-off originates. Flood control ends only when that run-off has safely reached the ocean.
>
> "The work, then of preventing floods (which annually cost citizens of the United States 250 million dollars in crops, equipment and other property damage) does not consist only of installing major engineering works along the main channelways of our trunk streams. It consists also of treating the land surface in such a way as to obtain maximum infiltration consistent with proper use of land for crops, pasture, forest and other purposes. It covers the orderly disposal of run-off from fields, pastures and woodlands through stabilized waterways and the temporary detention of run-off in small upland storage basins and temporary pools where practicable.
>
> "Grass—especially the sod-forming kinds—is a powerful weapon for holding rainfall where it hits the ground. It is therefore one of the best means known for preventing erosion.
>
> "From clean-tilled crops, grown at the ten older stations, the average soil loss over a period ranging from 6 to 11 years amounted to 42.10 tons an acre annually, and the water loss ranged from 2.50 to 40.32 per cent of the rainfall. In contrast from the same kind of land on the same stations, the corresponding losses from grassed fields were only 0.08 of a ton of soil per acre, and from 0.05 to 8.1 per cent of the rainfall. Expressed differently, the soil loss from clean tillage was 526 times as much as that from the same kind of land under grass and the greatest loss of water from the clean-cultivated field exceeded the corresponding water loss from grass by five times.
>
> "The greatest effectiveness of grass in holding up soil and storing water in the ground measured at these stations was at Temple, Texas. There, from black, waxy clay of the Texas black land, 20.58 tons of soil an acre (the 11-year average) were lost when corn was grown, along with 13.6 per cent of rainfall. From Bermuda grass grown on the same kind of land, receiving the same rainfall (an average of 32.74 in.), the soil loss was only 0.02 of a ton an acre; the water loss was 0.05 per cent of the precipitation. In other words, soil lost from corn was 1,029 times greater and the water loss 272 times greater than the corresponding losses from a cover of grass."

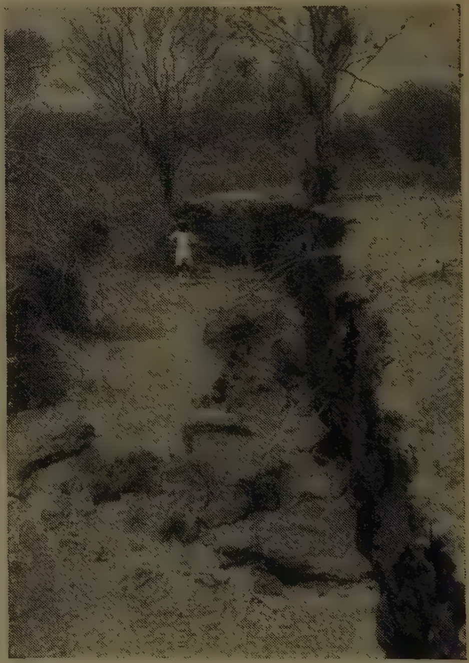

Fig. 2—Chunio, Mpwapwa district. Devastating erosion in one season due to inadequate grazing control, poor cultivation, and lack of suitable measures to divert flood-water from roads.

Other figures quoted are as high as 94.6 and 99.3 tons soil an acre lost and during heavy downpours up to 94.7 per cent immediate run-off. The effectiveness of grass cover against devasting wind erosion is also stressed and plainly demonstrated.

RESULTS OF EXPERIMENT IN RELATION TO THE PROBLEM OF SOIL EROSION IN GENERAL

Damage is usually most intense if heavy storms are experienced at the onset of the rains when the vegetal cover is poor or non-existent. As the experimental plots described above are only 1/80th acre in size and thoroughly protected from water coming from outside, the figures given in the tables are very conservative. It is therefore not surprising to see that wide gaping gullies appear almost over-night in denuded parts of the Mpwapwa and other districts when heavy downpours are experienced. Extensive parts of Ugogo are rapidly becoming a second Kondoa-Irangi where devastation has more or less reached its peak. The damage becomes more noticeable and the disastrous blows are more severely felt almost each successive season, especially during drought and famine years such as these which are now being experienced. Some areas which were settled only about two or three years ago are already desert-like with wide gaping chasms all over, while their utter destruction is rapidly in progress.

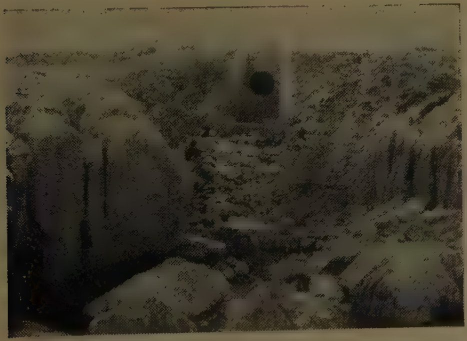

Fig. 3—Erosion in the Kondoa-Irangi district, caused by trampling by stock, incorrect cultivation, and lack of suitable measures to divert storm-water from culverts and bridges.

Perennial grasses such as *Cynodon plectostachyum*, *Cenchrus ciliaris* and *Chloris gayana* (Rhodes grass) are very firmly rooted and cannot generally be "pulled up by the root" either by grazing animals or by hand, as easily as is sometimes being proclaimed. They give excellent protection to the soil even when comparatively closely grazed or after cutting. The effectiveness of grass against the ravages of erosion and accelerated land deterioration is not sufficiently appreciated or adequately utilized especially in semi-arid areas where dry conditions and bare washed or wind-swept soil surfaces do not generally promote much spontaneous growth of these valuable soil-binding perennial species. If encouraged and properly utilized, these grasses would in many instances serve much more adequately to prevent erosion than *expensive* stone and cement structures which soon cave in and go down the drain.

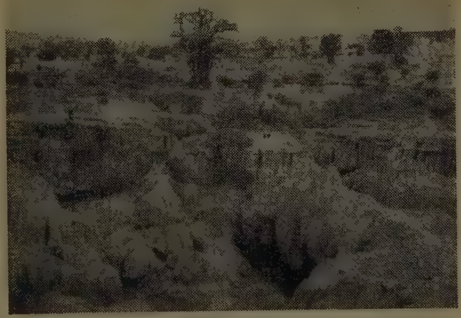

Fig. 4—Kondoa-Irangi district: Photograph taken immediately below the previous one which shows a road culvert. Uncontrolled flood-water causes complete devastation to vast areas of previously fertile productive land.

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TREE GROWTH ON A SEASONALLY DRY SWAMP IN EASTERN UGANDA

By J. E. M. Stephens, Forest Department, Uganda

(*Received for publication on 12th October, 1954*)

In the seasonal swamps of Teso District, Uganda, the only indigenous tree growth found is on ant hills. However, plantations of *Cassia siamea* Lam. and *Eucalyptus* spp. have been formed on these sites with varying degrees of success. Unfortunately the variations of growth in *Cassia* are extreme (*see* Figs. 1 and 2), and *Eucalyptus* may have a high mortality or fail altogether. Because good growth of both species could be obtained on such swamps it became desirable to find the reasons for variations in growth, and to find indicators of goods sites for new plantations. The probable causes of the variations in tree growth were found by an examination of the soils of a 25-acre plantation of *Cassia siamea* and *Eucalyptus saligna* Sm.

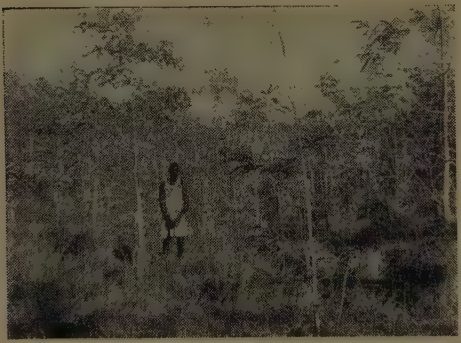

Fig. 1—A seepage site. "Cassia" apparently in check: note die-back of top branches.

Climate and Situation

The plantation examined is in a rainfall area of 52 in. per annum; there are peak falls in April–May and August, and there is a marked dry season from December to February. Dry spells frequently occur in the rainy months. The dry bulb temperatures vary from 66 to 92 degrees, and relative humidities from 36 to 83 per cent.

The district has a general elevation of 3,600 ft., and is cut up into a series of swampy valleys and low, gently sloping ridges. The plantation is sited at the head of one of these shallow valleys.

Water Relations and the Soils of the Plantation Locality

Water in excess of rainfall is received in the plantation from the run-off from adjacent ridges, and from seepage. Seepage water comes from the drainage of the ridges and wells up in definite, limited areas (called here seepage soils) where it often gives permanent springs. High water tables occur during the rains with brief flooding of the planatation. Water moves away either vertically through cracks in the clay or laterally through or across the top soils. During the dry season the water table sinks to great depths except in the seepage areas, where it remains within 5 ft. of the surface.

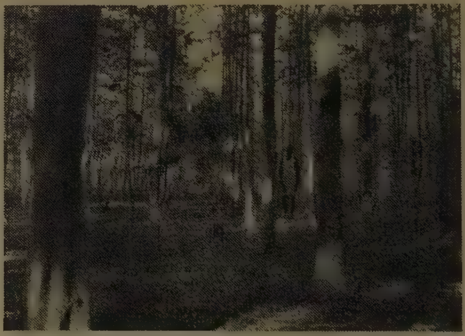

Fig. 2—A swamp bottom site. Best growth of "Cassia". About 70 yards from Fig. 1.

The soils of the Teso ridges have been described as degraded red earths (Griffith, 1948) [1]. The swamps are formed, or at least are influenced by, material washed down from the ridges. The swamp at the plantation can be divided into three soil phases. Starting from the lowest point in the valley and going up, these are grey swamp bottom, grey seepage and grey-fawn transitional soils. Thus, with the ridge soils, there is a four-linked catena, the transitional phase being transitional between grey and red earths.

The plantation site examined included each of the three lower phases of the catena. Soil pits showed that the profiles in each phase are clearly divided into top-soils and sub-soils (*see* Fig. 3). The top-soils are leached sands or clayey sands plus varying amounts of silt. The sub-soils are heavy clays showing varying degrees of cracking; these heavy clays have a higher nutrient status than the top-soils. (The lowest exchangeable base content measured was 0.5 Me per cent. of Ca, Na, K and Mn in a top-soil and the highest was 18.63 Me per cent in a sub-soil.)

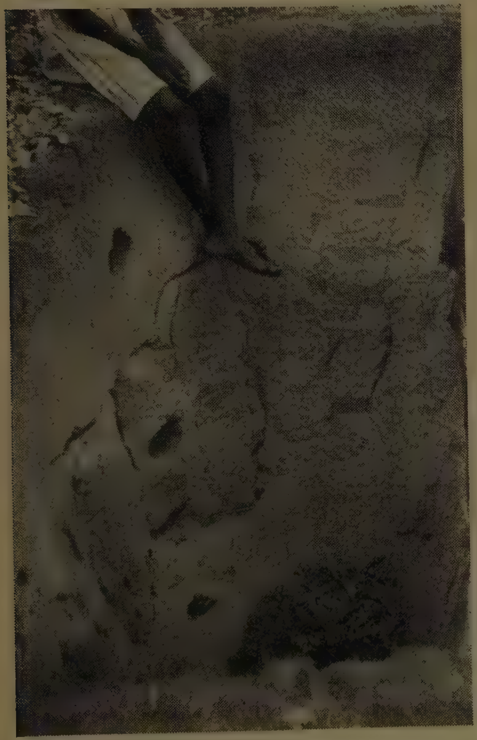

Fig. 3—A soil pit in swamp bottom showing differentiation into a sandy clay top-soil and a clay subsoil. The cracks in the clay are up to 1½ in. wide and contain a coarse sand.

The salient features of the three soil phases included in the plantation are:—

(*a*) The swamp bottom phase has a permeable, fairly friable top-soil and the rainy season water tables are generally lower, i.e. at about 4 ft. down, than in the other phases: presumably because of many permanently open cracks in the clay.

(*b*) The seepage phase has permanently high water tables which during the rains may not sink much below 1 ft. Reducing conditions are apparently severe here, probably because seepage water is poor in oxygen after its passage through the ridge soils.

(*c*) The transitional phase is extremely hard and compacted and the clay is but poorly cracked. The top-soils appear to be silted up, and the sub-soil has a fairly high proportion of sodium and is deflocculated.

Experimental Work

Heights of trees and depths of top-soil were measured over about five acres of the plantation. Soil samples were chemically analysed. Root profiles exposed in soil pits were drawn.

There was no apparent relationship between height growth of *Cassia* and depth of top-soil, nor chemical status of the soils.

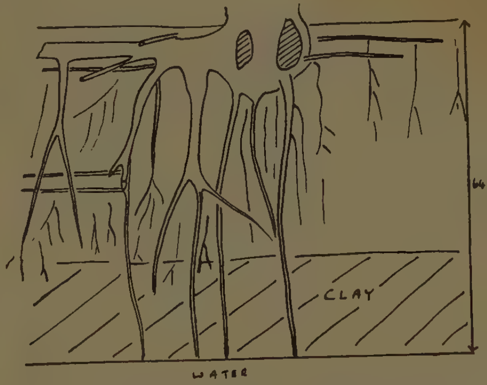

Fig. 4—Root profile of "C. siamea" on swamp bottom soil. Average height of surrounding trees, 38 ft.

The Plantation Growth

The growth of the six-year-old *Cassia* was associated with soil phases: good growth was obtained on swamp bottom and poor growth on transitional and seepage soils. The root profiles (Figs. 4–6) indicate that restriction of rooting is the cause of poor growth. Roots are apparently restricted in seepage soils by the permanently high water tables of water of poor aeration, and in transitional soils by the extreme hardness of the soils.

It appears that the growth of *Cassia* on the transitional and seepage phases is in check. This is indicated by the die-back of shoots on all trees (*see* Fig. 1). The checking of growth is presumably due to the constantly occurring deaths or weakening of roots confined near the soil surface: such roots are affected by desiccation during dry spells and by the poor aeration (Russell, 1953, p. 389) [2] and high temperatures which occur during flooding under a hot sun. Weakened roots may be attacked by fungi or termites. During most of the dry season the roots are probably sufficient only to maintain turgor: wilting is often seen in the last few weeks of the drought.

The poorly growing *Cassia* showed signs of nutrient deficiency. A red-green colour of the leaves might indicate a deficiency of nitrogen (Russell, 1953, p. 31). This may be because soils subject to alternate flooding under high temperatures and desiccation have little microbiological activity and therefore yield little nitrogen. Or the *Cassia* may be deficient of nutrients merely because of root restriction. The sickly looking trees on transitional and seepage soils never form canopy and grow in a welter of grass.

The good growth of *Cassia* on swamp bottom is supported by a well-distributed, deep root system. It is probable that the growing season is longer and available water and nutrients are more fully utilized here than on other phases. Feeding roots are able to ramify throughout the top-soil and the tap root and sinker roots are able to follow cracks deep into the clay. Root functions are probably never inhibited during the growing season because roots are not restricted near the soil surface. When the soil is drying out at the end of the rains the deep sinker roots probably bring up water, so that growth continues for some time (Russell, 1953, p. 423) [2], and at the beginning of the rains a strong root system can take immediate advantage of water in the soil. There are no signs of nutrient deficiencies and the trees are probably well supplied, for the feeding roots appear to tap the clay sub-soil as well as the surface soil for nutrients. It seems that root systems are not affected by the temporarily high water tables, presumably because the water is well aerated.

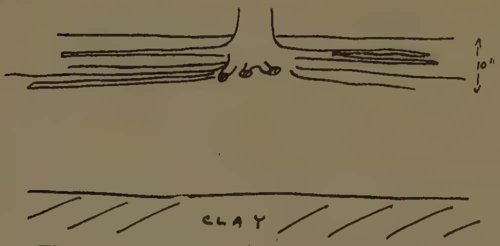

Fig. 5—Root profile of "C. siamea" on transitional soil. Average height of surrounding trees, 8 ft.

Cassia on swamp bottom forms complete canopy and eliminates grass so that less water is lost by evaporation from the soil or by grass transpiration than on the other phases.

The six-year-old *Eucalyptus saligna* in the plantation were planted on a seepage site. There was only one healthy survivor of the trees planted and this tree was examined. It had put out an extensive root system (*see* Fig. 7), but nearly all the root appeared heavily suberized and out of action. The water table at the tree remained at less than 1 ft. from the soil surface during the rains, and sank eventually to a lowest point of 5 ft. in the dry season. It seems possible that most of the growth of this tree is put on at the beginning and end of the rains, or even in the dry season, for the roots must function best when the soil is merely moist and the water table is low. Many of the eucalypts grew to about 35 ft. high before dying; and they exhibit drought crack as they die. It is probable that after five or six years a *Eucalyptus* on this site transpires more water than can be supplied by its roots.

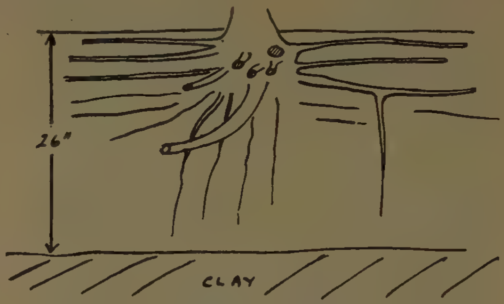

Fig. 6—Root profile of "C. siamea" in seepage soil. Average height of surrounding trees, 7 ft.

The natural vegetation of the plantation could be associated with soil phases. Swamp bottom soils had very few sedges and *Setaria sphacelata* (Schumach) Stapf and Hubbard was sometimes dominant; seepage soils had frequent sedges and abundant *Brachiaria soluta* Stapf and *Sorghum rigidifolium* Stapf; transitional soils had extensive stands of co-dominant *Hyparrhenia filipendula* (Hochst) Stapf and *H. dissoluta* (Steud) C. E. Hubbard. There was generally a sharp transition from the grasses of transitional to the grasses of seepage soils.

These "indicators" of soil phases were distinguished subjectively on 25 acres of swamp which had been protected from fire for six years.

Conclusions

Cassia must be able to develop deep roots in order to grow well on seasonal swamps. The swamp bottom phase provides conditions for deep rooting while the seepage and transitional phases do not.

Conditions on the seepage phase are inimical to good growth of *E. saligna.*

A good planation site for *Cassia* can be found in seasonally dry swamps by choosing the grey swamp bottom soils with the greatest average depth of rainy season water table, and avoiding areas with abundant sedges.

General Notes on Plantations in Seasonal Swamps in Teso

It is notable that the best growth of *Cassia* in swamps is always as good as, and generally better than, the best growth obtained on red earths.

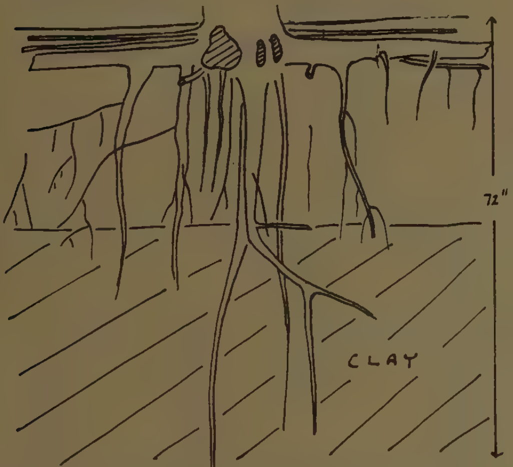

Fig. 7—Root profile of "E. saligna" in seepage soil. Height of tree about 35 ft.

Growth of *Eucalyptus* on swamps is better than that of *Cassia.* Nevertheless, on the good site for *Cassia* near swamp-head eucalypts more than six years old tend to die during the dry seasons. Dry season deaths of *Eucalyptus* are lessened or eliminated if the eucalypts are planted in the lower, wetter reaches of the swamp. Good *Cassia* sites can be obtained which require little or no drainage whereas good *Eucalyptus* sites require extensive drainage.

Any drainage systems on swamp bottom sites must be constructed with great care. After a heavy rainfall water moves extremely rapidly and in large amounts along the drains. The soils are erodible—even the sub-soil is cut up by the force of water—and therefore the banks and bottoms of all drains must be strongly stabilized, and all spillways, conduits, etc., must be of strong construction.

Plantations on swamp bottom could possibly be irrigated with seepage water during the dry season. A well-designed drainage system could distribute water in the dry season as well as remove excess water in the rains.

Comparison with Other Districts

Seasonal swamps elsewhere in the Eastern Province and in the Northern Province of Uganda are probably similar to the swamp described. Descriptions of *mbugas* and *dambos* show that they also have similarities. A small portion of the head of a swamp has been described in this paper: further down the swamp are found the large flat areas of cracking clay which are usually associated with the terms *mbuga* and *dambo.*

REFERENCES

[1] Griffith, G. "Provisional Account of the Soils of Uganda." P. 16 in "Proceedings of the First Commonwealth Conference on Tropical and Sub-Tropical Soils, 1948." *Tech. Commun. Bur. Soil Sci., Harpenden, No.* 46.

[2] Russell, E. J. Pp. 389 and 423, "Soil Conditions and Plant Growth". London, 1953.

E.A. MILK RECORDS OF LEADING COWS—JUNE TO DECEMBER, 1954

By the East Africa Milk Recording Scheme, P.O. Box 478, Nakuru, Kenya

CLASS I (UNDER 2 YEARS OLD)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	Lactation Records					
				No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F. (lb.) 10
B. R. McKenzie, Nakuru . .	Gingalili Juliana, *Jelsumer Wobbe Jan. 5th*	Friesland P	29–5–51	1st	21–4–53	7,914.00	305	3·89	307·85
Mizizi Farm, Nanyuki . .	Poincetta of Ober, A.R. (Imp.) *Majestic 3rd of Marsh Close.*	Guernsey P	25–5–51	1st	6–5–53	6,551·50	305	5·04	330·20
Mrs. A. R. H. Crampton, South Kinangop	Nyarumbwa, *Valentinus 3rd of Loads Moor.*	Guernsey N.P.	2–12–51	1st	23–11–53	5,869·50	288	4·44	260·61
Osirua Jerseys, Limuru . .	Lugano of the Lake, (Imp.) C.M., *La Fontaine Dreamster.*	Jersey P	11–10–51	1st	31–8–53	5,029·75	299	5·99	301·28
Lt. Col. R. D. Gordon, Nakuru	Jane, *Unknown.*	Jersey N.P.	31–7–51	1st	20–7–53	4,911·70	305	6·25	306·98
H. H. Peet, Nakuru	Solai Lady Anna 2nd, *Mickle Golden Grain.*	Shorthorn P	30–6–51	1st	3–3–53	6,194·90	305	4·17	258·33

CLASS II (UNDER 2½ YEARS OLD)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F. (lb.) 10
Drinmore Farm, Naivasha . .	Drinmore Ensa 4th, *Marriot Jupiter.*	Ayrshire P	23–2–51	1st	26–8–53	7,340·00	305	4·42	324·43
G. R. Hamilton-Gordon, Mweiga	Mary 53, *Unknown.*	Ayrshire N.P.	5–5–51	1st	21–10–53	4,400·00	287	4·86	213·84
B. R. McKenzie, Nakuru . .	Gingalili Lorna, *Rutje's Eduard 3rd.*	Friesland P	12–9–50	1st	22–12–52	7,103·40	303	4·16	295·50
L. F. A. Green, Limuru . .	Bobby 39, *Oldambtster Don.*	Friesland N.P.	11–4–51	1st	19–8–53	7,026·50	287	3·43	241·01
Rhodora Estates, Nakuru . .	Rhodora Marlene, A.R., *Valentine of Fernhill Park.*	Guernsey P	18–5–51	1st	23–9–53	6,466·40	305	5·75	371·82
P. E. L. Howard, Nakuru . .	Nzigu H.16, *Rose's Roberts Lad 2nd.*	Guernsey N.P.	3–10–51	1st	3–1–54	8,792·90	305	4·54	399·20
Dearlove and Jowitt, Ainabkoi	Southernwood Pioneer's Twinkle *Southernwood Edina's Pioneer.*	Jersey P	8–3–51	1st	8–8–53	6,494·50	305	6·54	424·74
Maj. & Mrs. L. B. L. Hughes, South Kinangop	Spring Song M.35–51, *Moyeni Designers S. Triumph.*	Jersey N.P.	4–4–51	1st	6–7–53	5,855·90	297	5·72	334·96
H. H. Peet, Nakuru	Solai Ruby Duchess, *Mickle Golden Grain.*	Shorthorn P	18–2–51	1st	1–6–53	4,895·20	305	4·16	203·64

P.—Pedigree. N.P.—Non-pedigree.

CLASS III (UNDER 3 YEARS OLD)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	LACTATION RECORDS No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F (lb.) 10
Kivulini Ltd., Molo	Kivulini Lexie 33rd, *Mtarakwa Neptune.*	Ayrshire P	29–9–50	2nd	25–8–53	7,408·50	305	4·34	321·53
Lesirko Ltd., Ol' Kalou ..	Lesirko 934, *Auchen Gilbert.*	Ayrshire N.P.	7–1–51	1st	27–9–53	6,854·70	305	3·91	268·02
The Lord Waterpark, Subukia	Nderit Hardy's Guava, *Tusogo Hardy.*	Friesland P	25–7–50	1st	11–5–53	8,057·30	305	3·68	296·51
Manera Farm, Naivasha ..	No. 545, *Unknown.*	Friesland N.P.	Unknown	1st	17–9–53	8,578·50	305	3·55	304·54
Blundell Estate, Nakuru ..	Cardington Fleurette, A.R., *Ware Rose's Butterpat's Governor.*	Guernsey P	2–3–51	1st	15–9–53	7,152·05	305	5·31	379·77
S. S. Bastard and Son, Sotik..	Nyatundo 2nd No. 178, *Primroses Countryman of Ray.*	Guernsey N.P.	10–9–50	1st	3–7–53	6,361·70	305	4·88	310·45
Maj. & Mrs. L. B. L. Hughes, South Kinangop	Felbridge Senator's Primula, *Felbridge Designer's Senator.*	Jersey P	6–1–51	1st	3–10–53	6,498·30	305	6·29	408·74
D. E. Fielden, Nakuru ..	Bamba IX 322, *Oxford Boy of Les Hetres.*	Jersey N.P.	15–11–50	2nd	2–11–53	4,479·00	252	6·76	302·83
Keringet Estates, Molo ..	Higherden Walnut Stella 6th (Imp.), *Hathenshaw Royal Mase 3rd.*	Shorthorn P	9–1–50	1st	28–10–52	7,106·04	305	3·86	274·29
H. H. Peet, Nakuru	Baffle 8th, *Unknown.*	Shorthorn N.P.	Unknown	1st 2nd	21–5–52 4–6–53	6,642·60 8,600·20	287 305	4·33 4·44	287·62 381·85

CLASS IV (UNDER 4 YEARS OLD)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F (lb.) 10
A. T. Hales, Eldoret ..	Doinyo Lessos Jewel, *Benmore Yeoman.*	Ayrshire P	6–7–50	2nd	21–9–53	11,222·20	269	3·96	444·40
G. R. Hamilton-Gordon, Mweiga	Parigari 30, *Unknown.*	Ayrshire N.P.	11–11–49	1st	19–9–53	6,430·00	304	5·29	340·15
B. R. McKenzie, Nakuru ..	Tusogo Don Possum, *Oldambtster Don.*	Friesland P	16–12–49	1st	18–8–53	13,970·20	305	3·27	456·83
Barclay Estates Ltd., Menengai	Soi 1187, *Oldambtster Jan.*	Friesland N.P.	18–10–50	1st	11–11–53	6,180·00	305	5·42	334·96
J. D. Heath, Endebess ..	Princess Minx of La Villiaze (Imp.) A.R., *Gacheres Hero.*	Guernsey P	27–10–49	1st 2nd	6–8–52 28–9–53	7,322·60 7,907·20	305 305	5·08 5·12	371·99 404·85
P. E. L. Howard, Nakuru ..	Moselle H.8, *Unknown.*	Guernsey N.P.	Feb., 1950	1st	12–9–53	8,658·30	305	4·41	381·83
Rodericklea Ltd., Limuru ..	Pearcelands Daisy 3rd, *Grassvale Silvermines 4th.*	Jersey P	29–11–50	1st	3–12–53	6,724·50	305	6·03	405·49
D. E. Fielden, Nakuru ..	Kabai IV 267 *Osirua Jupiter*	Jersey N.P.	6–12–49	1st 2nd	31–1–52 9–7–53	8,795·00 8,526·00	365 305	4·82 5·08	423·92 433·12
Keringet Estates, Molo ..	Hathenshaw Wild Eyes 8th (Imp.), *Hathenshaw Lord Foggathorpe 5th.*	Shorthorn P	5–10–49	1st 2nd	21–5–52 29,5–53	5,891·75 6,437·20	305 305	3·41 3·57	200·91 229·81
G. S. Ransom, Kiambu ..	Borana II, *Kalmscott Golden Duke*	Shorthorn N.P.	28–5–49	1st	24–3–53	9,178·25	305	3·54	324·91

P.=Pedigree. NP.=Non-pedigree

CLASS V (UNDER 5 YEARS OLD)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	Lactation Records: No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F. (lb.) 10
Hafod Estates, Limuru . .	Llannerch Liquid 2nd (Imp.), *Barwheys Bell Boy.*	Ayrshire P	9–11–48	1st	19–5–51	9,226·25	305	3·95	364·44
				2nd	9–6–52	11,231·60	305	3·14	352·67
				3rd	26–5–53	10,872·50	303	3·61	392·50
Kambala Estate, Molo . .	Metsa No. 4, *Mtarakwa Neptune.*	Ayrshire N.P.	29–11–48	1st	16–10–51	6,334·60	266	4·13	261·62
				2nd	16–10–52	5,767·80	257	3·87	223·21
				3rd	24–9–53	8,245·80	305	3·99	329·01
B. R. McKenzie, Nakuru	Glenstuart Peace (Imp.), *Glenstuart Netherland Victory.*	Friesland P	26–9–48	1st	30–12–52	12,873·60	305	3·86	496·92
Hill Crest Farm, Limuru . .	Samburia D.9, *Unknown.*	Friesland N.P.	10–10–48	1st	15–8–53	7,631·50	305	4·88	372·42
Blundell Estate, Nakuru . .	Ware Lively 13th (Imp.) A.R., *Butterparts' Triumph of Ware*	Guernsey P	25–2–49	1st	2–6–51	6,806·60	286	4·36	296·77
				2nd	30–5–52	11,730·40	305	4·20	492·68
				3rd	5–8–53	8,525·90	305	4·84	412·65
Blundell Estate, Nakuru . .	Karoona C.7, *Unknown.*	Guernsey N.P.	24–4–49	1st	5–6–52	6,784·70	305	4·35	295·13
				2nd	15–6–53	7,476·10	305	4·32	322·97
Rodericklea Ltd., Limuru	Travalgan Starbright 43rd O.M., *Mornmoot Northwood Beau.*	Jersey P	7–6–48	1st	28–7–51	5,962·75	258	4·97	296·35
				2nd	6–5–52	7,055·50	305	5·20	366·89
				3rd	28–5–53	7,687·50	305	5·81	446·64
D. E. Fielden, Nakuru . .	Sindet 3rd, 271 *Oxford Boy of Les Hetres.*	Jersey N.P.	19–12–49	1st	21–6–52	4,552·30	254	6·51	296·35
				2nd	30–4–53	5,148·30	270	5·91	304·26
				3rd	22–3–54	8,081·55	252	6·15	497·02
Keringet Estates, Molo . .	Denton Mary Wild Eyes 4th (Imp.), *Eaton Hussar.*	Shorthorn P	9–9–48	1st	29–10–52	7,818·45	305	4·03	315·08
H. H. Peet, Nakuru . .	Baffle 7th, *Unknown.*	Shorthorn N.P.	Unknown	1st	4–12–51	7,805·50	343	3·32	259·14
				2nd	30–1–53	6,723·40	305	4·36	293·14

P.—Pedigree. N.P.—Non-pedigree.

CLASS VI (MATURE)

Name and Address of Owner 1	Name of Cow and Sire 2	Breed 3	Date of Birth 4	Lactation Records: No. of Lactation 5	Calving Dates 6	Milk Yield (lb.) 7	Days 8	B.F. % 9	B.F. (lb.) 10
Kabazi Estates, Nakuru . .	Harting Gaiety (Imp.), *Bargower Tablet.*	Ayrshire P	7–1–46	3rd	13–2–51	12,007·80	329	4·03	483·91
				4th	30–3–52	12,090·10	305	4·40	531·97
				5th	7–8–53	12,689·70	305	4·42	560·88
J. L. Downey, Limuru . .	Cherry 14th, *Mtarakwa Masterpiece.*	Ayrshire N.P.	22–9–47	1st	18–8–53	15,030·80	280	3·93	590·71
B. R. McKenzie, Nakuru	Karirana Janine, *Burnet Julian.*	Friesland P	27–7–46	2nd	5–9–50	16,399·50	305	3·18	521·50
				3rd	8–2–52	15,770·20	305	2·80	441·57
				4th	8–7–53	17,338·90	305	3·15	546·18
W. K. Bastard, Nanyuki . .	Rendia 226, *Carnation Walker Superior.*	Friesland N.P.	7–6–44	1st	14–11–49	14,703·80	541	4·10	602·86
				2nd	1–4–53	15,446·90	305	3·73	576·17
Olbonata Ltd., Nakuru . .	Cherkley Regent's Isobella, A.R., *Tackley Regent 9th.*	Guersney P	17–3–46	1st	20–3–51	10,015·90	365	4·52	452·72
				2nd	26–6–52	8,323·60	273	4·26	354·58
				3rd	27–7–53	9,900·23	305	4·24	419·77
J. D. Heath, Endebess . .	Peggy, *Unknown.*	Guernsey N.P.	Unknown	1st	25–10–51	8,823·00	312	4·93	434·97
				2nd	28–10–52	7,555·50	281	4·40	332·44
				3rd	3–10–53	10,194·00	305	4·77	486·25
R. A. Clay, Elburgon . .	Trefoil Beauty's Bluebell, C.M., *Maharajah of La Commune.*	Jersey P	27–5–48	2nd	13–9–51	7,162·25	230	4·27	305·83
				3rd	5–10–52	7,726·75	248	4·42	341·52
				4th	15–11–53	12,569·50	303	4·55	571·91
D. E. Fielden, Nakuru . .	Kongoni 1st· 72, O.M., M.M., G.M., *Unknown.*	Jersey N.P.	Unknown	3rd	25–9–51	14,108·50	305	5·50	775·97
				4th	30–11–52	10,507·75	219	5·43	570·57
				5th	23–10–53	12,411·20	305	5·64	699.99
H. H. Peet, Nakuru . .	Solai Rosebud, *Primestone Patrician 3rd.*	Shorthorn P	23–5–46	1st	27–12–50	6,343·40	280	4·43	218·01
				2nd	23–1–52	7,852·80	286	3·94	309·40
				3rd	14–4–53	6,463·90	239	4·70	303·80
H. H. Peet, Nakuru . .	Berenice 2nd, *Mickle Golden Grain.*	Shorthorn N.P.	30–12–47	1st	26–9–50	9,493·40	365	4·22	398·72
				2nd	26–1–52	9,445·30	305	4·10	387·26
				3rd	3–3–53	9,562·80	305	4·08	390·16

P.—Pedigree. N.P.—Non-pedigree.

NUTRITIVE VALUE OF GREEN INDIGOFERA SUBULATA HERBAGE

By A. Rogerson, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.

(Received for publication on 3rd February, 1955)

The Food and Agriculture Organization of the United Nations recently published a booklet entitled *Legumes in Agriculture* (1953) [1]. In referring to Indigofera the publication states: "This genus comprises about 300 species found in all tropical regions and as far down as the Cape in Africa. They are usually shrubs or perennial herbs. . . . The genus Indigofera comprises certain species which apparently cannot be eaten by stock with impunity (*I. hirsuta*), others which are sometimes poisonous (*I. endecaphylla*), and a great many species which are invariably poisonous."

Of *Indigofera retroflexa* the publication states (p. 281): "In Southern Rhodesia and Kenya, *I retroflexa* (= *I. subulata*) is considered promising as a forage crop. It is a perennial 2 ft. to 3 ft. high, resistant to drought and light frosts."

No mention was made of this species being toxic, and further information about its possible toxicity and feeding value seemed urgently desirable. The following experiment was undertaken with these objectives in mind, at the request of the Botanist of the Kenya Agricultural Department, with herbage grown at the Scott Agricultural Laboratories.

The *Indigofera subulata* used for this experiment was collected daily and within an hour of cutting and collection was chaffed and fed. It was given to four sheep twice daily and a total of 2,000 g. was fed to each sheep per day. It must be stressed that, apart from the legume itself, no other food was given to the sheep. After a week on this diet two sheep showed a tendency to scour—not unexpected in view of the high protein content of the legume—and these two sheep were removed from the experiment. Ten days after the first feeding of the Indigofera the trial itself was commenced with the remaining two sheep, both of which had readily eaten their entire ration. The period of collection lasted ten days; one sheep ate its ration readily throughout the whole period and showed no signs of any ill effects. The other sheep showed a tendency to scour on the eighth day of the trial and this animal was then removed from the experiment. No sign of poisoning was observed in either of the four animals at any time during the feeding of the legume. In practice, of course, no animal would ever be fed entirely on such a succulent legume. The reason for so doing in the experiment was to apply a severe test for possible toxicity as well as to obtain a feeding value for the legume, uncomplicated by any interactions which could arise from the feeding of a fibrous basal diet.

RESULTS

The dry matter content of the Indigofera herbage was 24.3 per cent.

Sheep A.—Food ingested—4,860 g. *Indigofera subulata* (D.M. basis).
Dry weight fæces 2,183 g.
Fæcal crude protein 223.8 g.

Sheep B.—Food ingested—3,888 g. *Indigofera subulata* (D.M. basis).
Dry weight fæces 1,718 g.
Fæcal crude protein 180.3 g.

The feeding value of *Indigofera subulata* is shown in Table 1.

TABLE 1.—NUTRITIVE VALUE OF INDIGOFERA SUBULATA (DRY MATTER BASIS)

	Analysis	DIGESTIBILITY		
		Sheep A	Sheep B	Mean
	%	%	%	%
Crude Protein . .	16·78	72·6	72·4	72·5
Ether Extractives . .	1·06	43·1	43·4	43·3
Crude Fibre	31·81	45·9	46·7	46·3
Nitrogen-free Extractives	40·85	58·6	59·3	59·0
True Protein	13·47	55·1	55·8	55·5
Dry Matter	100·00	67·3	67·8	67·6
Starch Equivalent		39·1	39·6	39·4
Digestible Crude Protein . .		12·18	12·15	12·17
Protein Equivalent		10·6	10·6	10·6

The figures in Table 1 for *Indigofera subulata* compare very closely with those given by Woodman, 1948 [2], for the temperate legumes, vetch and sainfoin. Crude protein, crude fibre, starch equivalent and nutritive ratio are very similar to the European legumes and *Indigofera subulata* would seem to be their East African nutritional counterpart.

[1] Legumes in Agriculture, F.A.O. Agricultural Studies, No. 21, April, 1953, 165 and 279.

[2] Rations for Livestock, *Min. of Ag. and Fish.* No. 48, 1948.

THE POSSIBILITIES OF TREE-BREEDING AND OF TREE SEED ORCHARDS IN EAST AFRICA

By A. L. Griffith, E.A. Agriculture and Forestry Research Organization

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Forestry, unlike agriculture, is a long-term job and, whereas in agriculture the time needed for a study from one generation to another is often a matter of months, in forestry the rotation from one generation to another is a long period of years. In Europe it is often 100 to 150 years, and even here with our fast-growing exotic species it is a matter of some 30 years at least. Thus the precise judgment of forest problems of heredity is difficult and we are forced to reason largely with probabilities and analogous evidence from agriculture.

Long-term progeny tests with forest trees started about 1900 and the results of these tests are of the greatest importance to our approach to the problem of racial improvement in forestry. Some of the earliest work on the hereditary basis of stem form, type of branching and variation in growth rate was done by Prof. Opperman in Denmark. This showed that straight or crooked growth and coarse or fine branching were largely hereditary. Work by Prof. Burger in Switzerland on pine showed similar results. Prof. Dengler of Eberswalde showed that the type of bole and branching in pine are to a large extent genetically determined. Dr. Zederbauer worked with pine in Austria and Dr. Larsen in Denmark has contributed a great deal of knowledge of the hereditary variations of many of our forest trees, notably of larch, beech and alder. Much later work followed including that of H. G. Champion in India who showed that the twisted grain of chir pine (*P. longifolia*) was a hereditary character.

Prof. Lindquist of Sweden summed up the position by saying that "the results of these experiments justify the conclusion that certain of the characteristics of our forest trees which are most important from a forestry point of view such as rapidity of growth, branch and bole types, etc., are subject to hereditary variation of which practical use should be made . . . (provided that) one proceeds with care and does not let the thought of heredity obscure the fact that environmental conditions generally are, and will be, the dominant factors for the development of high-grade timber in our forests".

In this work Scandinavia leads the world and has been through the various stages of basic research by the pure scientists, technology by the horticulturist-nurseryman and is now in the stage of field practice by the forester. I have recently been fortunate enough to go to Scandinavia and meet some of the scientists and the technicians and foresters who are doing the field work. This article is the result of the tour.

REASON FOR THE INTENSIVE WORK IN SCANDINAVIA

The people of Scandinavia, like most other peoples of the world, at first thought that they had unlimited forest resources; and so they had for the population and conditions of transport of many centuries ago. The first to cut the forests for timber for special purposes were the Vikings who wanted special sizes of the very best timber for their ships which went all over the world. But, of course, at the same time timber round the villages was being cut for housing, fuel, etc.

As the centuries went on, these special sizes and special grades became more and more difficult to find, and more and more timber and fuel was being cut for village use. In consequence about the year 1700 a diameter limit was put on timber that was allowed to be cut, and again as time went on and the population grew, the diameter limit was reduced and reduced.

These cutting systems of selection felling and then diameter-limit felling were just "creaming" the forest and as no plantation work was done and natural regeneration was entirely relied on, the mother trees and their resulting progeny got poorer and poorer, generation by generation. Even when artificial planting was done the seed used was that which was easiest to collect and this was the seed from the degenerated wolf trees which usually have low height, bad form, and a large low-spreading crown which had survived near the villages, i.e. the worst possible seed.

About 1900 this situation was realized and it was found by extensive exploration of difficult parts of the country that the magnificent trees of the past still did exist in places which were difficult to get to and from which it was impossible to extract the timber at a profit. Hence they had been allowed to live and regenerate without interference and the stock had not degenerated. The realization of the situation caused the beginning of scientific work in progeny testing and tree breeding.

Forestry of the Future

In this century wood has started to be used in many other ways than as first-class timber. This caused many arguments about the necessity for the expense of breeding "super" trees. Apart from high-grade big timber the trees are used for ordinary housing purposes and pit props. Wood is also being used as a raw material for industry such as paper pulp, rayon, plastics, etc. It is, however, obvious that for whatever object the forest is raised one major consideration must be the growing of the greatest volume per acre in the shortest time of the size, shape and quality required. It is also considered that (anyway in the foreseeable future) there will always be a market for high-grade timber. Further it is as cheap to raise a high-grade forest crop as a poor-grade crop.

What is Happening to our Natural Indigenous Timbers?

Although forest working in East Africa is measured only in years or tens of years and with a small population as compared with the many centuries of working in Scandinavia with a growing intensity of population, yet the same early processes are going on. We are still in the stage of "creaming" our indigenous forests and even in the raising of artificial plantations far too little regard is still paid to the quality of the seed collected. It is necessary for us to think very seriously of where we are trending. All too often also one hears opinions such as that economically workable podo and cedar have been nearly exhausted.

Difficulties of our Softwood Planting

Although the trend of our indigenous forest working needs serious consideration, it will be a very long time before degradation such as happened in Scandinavia will occur. Our more immediate problems are with our introduced softwoods. We have to import a reat deal of our seed, the cost of that seed is getting higher and higher and we have little or no control over the provenance and the quality of the seed we receive. It may be many years before we realize that we have ourselves imported or have been supplied with a poor strain of a species. One has only to look round the territories to see the good, bad, and indifferent introductions that have been made over the past 30 years. Some introductions have been very good indeed; but we are often unable to repeat them because the old records of the seed origin have been lost in the course of time.

One of our greatest troubles comes from the fact that we have made introductions from many countries and climates, and in doing so have given opportunities for hybridization between species which have been brought together from different habitats. In East Africa there is little differentiation between our summer and winter seasons and in consequence flowering periods are often spasmodic, prolonged, and overlap between species. Examples are the cypresses which have been brought together and the wattles whose flowering seasons often overlap. The gums belong to a genus which has not yet settled down and has a large number of species which even in their own country are constantly hybridizing. Hence although we may have made a first-class introduction, we cannot trust the seed we collect from it. An example of a good introduction in Kenya is the Elburgon *Cupressus lusitanica* which is often crossed by bad types and by a disease-susceptible species such as *C. macrocarpa.* The problems of tree breeding have thus been forced upon us at a very early stage in our forestry. What can we do, or what are we doing about it? The easiest answer is first to describe how the Scandinavians tackled their problem.

The Swedish Work

Seed collection.—The first improvement was to try and collect seed from the best trees of the best stands. It was not sufficient to collect seed from a good tree in a generally poor stand, because one only has control over one of the parents. An all-Scandinavian survey was carried out and the very best stands selected. Very high standards were set for the criteria of a good stand and in those stands any tree showing any inferior characteristics was ruthlessly cut out. Thinning was also done round the best trees in the stand in order to stimulate crown development and the setting of cones. These elite trees are, however, very big and difficulty was experienced in collecting the cones. They were also intended for prolonged seed collection. Hence the older methods of collection by climbing the trees with nailed boots and climbing irons and the cutting off of the fruiting branches was converted to the use of ladders and the wearing of rubber shoes and the collection of the cones by hand. For some distance around the seed-stands all trees with unfavourable characteristics were felled and barriers erected (usually with living trees) in order to try to prevent as far as possible pollen from poor trees fertilizing the good trees. This collection of the best seed possible must be followed in nursery practice by very heavy culling so that only the best plants resulting from this highly selected seed are planted out. This work was a great step forward but not the final answer, for the seed was difficult and expensive to collect and cross-pollination by bad types was only reduced but not eliminated. The answer lay in bringing the stock that was wanted for breeding from the "back of beyond" to the vicinity of a research station where, by the use of suitable techniques, a large number of cuttings or grafts of the required trees could be produced and, by methods analogous to the raising of fruit tree orchards, kept to a convenient size and shape for seed production, and easy and cheap seed collection. The term "forest tree seed orchards" has come into use to described the plantations of trees specially grown for this purpose.

Seed orchards.—The above work caused Prof. Lindquist of the Gothenbuerg Botanical Garden and Professor of Forestry at the Royal College of Forestry, Stockholm, to seek the aid of Mr. Holger Jensen of Ramlösa, Hälsingborg, one of the ablest nurserymen in Sweden. Prof. Lindquist had a wide experience of breeding and genetics and Mr. Jensen's family for generations had been nurserymen at Ramlösa working in a practical and economic way with fruit trees. These two friends got together and worked out plans for seed orchards to provide first-class seed for the whole country; but as so often happens in such circumstances neither institutions nor authorities nor government appeared to be interested in the project and would provide no money. Lindquist and Jensen, however, were not to be deterred and started work on their own, but their work was so spectacular that in a comparatively few years they got all the official backing and money required. It should, however, be particularly noted that they believed in their subject so completely and were so loyal to their country that they started on their own with their own money, almost as a hobby.

The premises of the plan were—

(*a*) that the propagation of the elite trees should be made on a large scale and aim at a seed production sufficient for the whole country;

(*b*) that after a very strict survey of each source of elite trees, they should be propagated by the grafting procedure of Dr. Syrach Larsen of Denmark;

(*c*) that true seed orchards should be established with this grafted material (i.e. not ordinary forest stands);

(*d*) that the growth of the seed trees in the orchards should be kept as low as possible by grafting on to particularly slow-growing stocks (to avoid the costs and difficulties of collecting seed from tall trees);

(*e*) that flowering and fruiting should be stimulated by the same methods as are used in modern intensive fruit orchards, e.g. strangulation, bark-ringing, root pruning, etc.; and

(*f*) that when selecting elite trees for propagation one must take into consideration that the mother tree must show a strong tendency to flower frequently and profusely.

The country was divided into a number of provenance areas for each species and in each area elite stands were selected. From these elite stands after several years of observation on fruting, etc., a number of clones were decided upon as being the best and most suitable the country could produce. There was and still is a difference of opinion between the Swedes and the Danes on the number of clones to be selected in each provenance area, the former being content with about ten while the latter insist on 25 to 30. As already explained these best trees in the best stands were usually very difficult of access and hence required to be moved to research stations where all facilities for the work existed.

Material was taken from them to Ramlösa and propagated vegetatively to provide the material for future grafting work. These sources of grafting material "stored" as living trees at the research stations are referred to by the Scandinavians as "archives or tree banks", a very appropriate name. Material from the tree banks was grafted on to slow-growing young stocks and when a sufficient number of the grafts had taken the plants were planted out at a wide spacing just as in an ordinary orchard and they are treated as ordinary fruit trees. Present experience shows that the spacing should be about 15 ft. by 15 ft. and up to 20 ft. by 20 ft. and even more according to the species. They are kept small and forced to flower and fruit precociously and in profusion by heavy root pruning, shoot pruning and strangulation. An actual count by Dr. Syrach Larsen working in Denmark with pine showed in 1945 that 34 ten-year-old grafts between 1.85 m. and 3.15 m. (i.e. up to 10 ft. high) yielded 1,302 fertilized female cones. This is about 65,000 cones per ha. and represents at least half a million plants. In these orchards if at any time any unwanted characters develop the tree is cut out. Even so, modern experience is that there is a certain amount of variation still in these carefully raised trees and hand pollination must be done. In addition, of course, the orchards are heavily screened on the outside to prevent the entry of unwanted pollen. The work has been successful with a number of species and strains of species such as pines, spruce, larch, alder, oak, birch (particularly of figured wood such as brown curly birch, ice birch, flamy birch, glossy birch, etc.), ash and walnut. Finally, an orchard has been established of a very frost- and cold-hardy variety of yew (*Taxus baccata*) from middle Europe. In most of the orchards even in the cold climate of Sweden profuse fruiting has been induced at the early age of seven to ten years. Of particular interest in this Swedish work is that what started as a very highly technical job, has been found not to be so as the years have gone on. To start with, vegetative propagation and grafting were all done in greenhouses under very carefully controlled conditions of temperature, humidity and soil moisture, but with some species they are now able to do the work in the open without any elaborate precautions.

POSSIBILITIES IN EAST AFRICA

As already explained, our immediate problem is our softwoods, and the indigenous hardwords a later problem. Our main softwoods are cypresses and pines, and already in Kenya in the last few years seed stands have been selected and cleaned up both within and without and methods of seed collection vastly improved. Each year that goes on sees a steady improvement in the cypress seed collected as shown by the regularity of the progeny. In addition progeny plots have been raised by the Kenya Forest Department from a number of the best elite trees; and, as the poorer strains of these are cut out, the quality of the seed is likely to be further improved. As cypress seeds profusely at a young age we are in sight of really good quality seed in quantity, particularly if we can do hand pollination on a big enough scale. Indeed this may even be the solution of the cypress problem. With the pines, however, the situation is very different. In general they do not begin to seed nearly as early as cypress and one at least of our most important species (*Pinus radiata*), on present experience, is a very shy producer of seed. Further, most of our pine introductions are too recent for us really to be sure of what we want to propagate. A difficulty experienced with pines in Europe is that some of the selected cones have been found to seed only very lightly and in some cases have even been sterile. Kenya has already started on the selection of good stands for the careful collection of pine seed.

RESEARCH WORK

Research work on tree breeding has been started at E.A.A.F.R.O. but we are only in the very early stages and work has only been on a very small scale. We have succeeded in raising cypress by vegetative propagation and we have succeeded in grafting several species of pine on pine and cypress on cypress.

The subject was discussed interterritorially at a recent meeting of the Silviculture Specialist Committee. This Committee agreed that the development of tree-breeding methods and the establishment of tree-seed orchards would be of great benefit to East Africa and recommend that E.A.A.F.R.O. should give high priority to the study of techniques for important species and conditions. The Forestry Technical Co-ordinating Committee agreed with this resolution and thus we now have official backing for the pursuance of the work.

It must, however, be emphasized that this work will take a number of years to perfect; and if we are collecting super seed from seed orchards in ten years from now, we shall have done very well indeed.

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The bibliography of this subject is largely in Swedish, Danish or German and, therefore, for those interested I quote two very easily readable publications written in English which themselves give references to most publications on this interesting subject.

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Jensen, H., 1954. The Establishment of Forest Tree Seed Orchards at Ramlösa, 1941–1954. *Acta Horti Gothoburgensis 19,* (5): 157–192.

NUTRITIVE VALUES OF LOCALLY PREPARED COTTONSEED AND LINSEED CAKES

By **A. Rogerson, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.**

(*Received for publication on* 18*th November*, 1954)

These experiments were carried out with Merino-type wethers, the technique and analytical procedures being identical with the methods detailed in earlier work (Rogerson, 1954 and 1955).

COTTONSEED CAKE

Rations fed to two sheep:—

600 g. hay + 100 g. cottonseed cake daily.

The meadow hay fed as the basal diet had the composition and nutritive value given in Table I:—

TABLE I.—MEADOW HAY BASAL DIET

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	9·97	56·4
Ether Extractives ..	2·78	60·3
Crude Fibre	33·03	66·2
Nitrogen-free Extractives	44·70	56·0
True Protein	8·47	48·6
Dry Matter	100·00	57·5
Organic Matter	89·26	59·3

Calculated Starch Equivalent	36·2
Calculated Protein Equivalent	4·9

Results

Sheep A.—Food ingested—5,337 g. hay + 919 g. cottonseed cake (D.M. basis).

Dry weight fæces 2,441 g.

Fæcal crude protein (wet analysis) 297.5 g.

Sheep B.—Food ingested—5,347 g. hay + 919 g. cottonseed cake (D.M. basis).

Dry weight fæces 2,433 g.

Fæcal crude protein (wet analysis) 295.0 g.

Assuming the hay portion of the ration to be digested as when fed alone, then the nutritive value of the cottonseed cake can be assessed as in Table II:—

TABLE II.—NUTRITIVE VALUE OF COTTONSEED CAKE

	Dry Matter Analysis	Digestibility		
		A	B	Mean
	%	%	%	%
Crude Protein	40·65	82·5	83·2	82·9
Ether Extractives ..	6·00	94·4	90·0	92·2
Crude Fibre..	17·58	100·0	100·0	100·0
Nitrogen-free Extractives	28·99	58·0	59·4	58·7
True Protein	37·17	88·6	89·0	88·8
Dry Matter..	100·00	81·2	82·5	81·9
Organic Matter	93·22	83·2	84·0	83·6
Calculated Starch Equivalent		77·2	77·2	77·2 (V No. (97
Calculated Protein Equivalent		33·2	33·5	33·4
Calculated Starch Equivalent (fibre factor) ..		69·4	69·4	69·4

It is interesting to compare the nutritive value of this particular sample of cottonseed cake with the analysis given by Woodman (1948) for decorticated cottonseed cake. Woodman's results expressed on dry matter basis are quoted in Table III.

TABLE III.—WOODMAN'S FIGURES FOR COTTONSEED CAKE

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	45·3	85·0
Ether Extractives ..	8·8	94·3
Crude Fibre	8·6	27·9
Nitrogen-free Extractives..	29·2	66·8

Starch Equivalent	75·2
Protein Equivalent	38·1

While the total quantities and digestibilities of crude protein, ether extractives and nitrogen-free extractives are fairly similar in the two samples, the local cottonseed cake has a considerably higher crude fibre content, which suggests that the hulls were incompletely removed during the local decorticating process. From the experimental results obtained, it is not possible to give an accurate figure for the digestibility of the fibre. The results actually recorded, 118 per cent and 120 per cent respectively for the two sheep, infer that the feeding of cottonseed cake has had the general effect of increasing the digestible crude fibre content of the hay. As they stand, the figures are at variance with those of Woodman, which show the crude fibre to be relatively indigestible. The fact remains, however, that the local cottonseed cake is a particularly valuable concentrate, being a useful source of starch equivalent and rich in digestible crude protein.

LINSEED CAKE

The rations fed to two sheep were 400 g. Kikuyu grass hay + 100 g. linseed cake daily. The hay fed as the basal diet had the composition and nutritive value given in Table IV.

TABLE IV.—HAY FED AS BASAL DIET

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	12·07	53·2
Ether Extractives	0·78	Negative
Crude Fibre	35·24	67·1
Nitrogen-free Extractives	41·42	49·8
True Protein	9·71	44·0
Dry Matter	100·00	54·4
Organic Matter	89·51	56·0

Calculated Starch Equivalent	29·9
Calculated Protein Equivalent	5·4

Results

Sheep A.—Food ingested—3,172 g. hay + 897 g. linseed cake (D.M. basis).

Dry weight fæces 1,672 g.

Fæcal crude protein (wet analysis) 219.7 g.

Sheep B.—Food ingested—3,172 g. hay + 897 g. linseed cake (D.M. basis).

Dry weight fæces 1,678 g.

Fæcal crude protein (wet analysis) 211.6 g.

Assuming the hay portion of the ration to be digested as when fed alone, then the nutritive value of the linseed cake can be assessed as in Table V:—

TABLE V.—NUTRITIVE VALUE OF LINSEED CAKE

	Dry Matter Analysis	Digestibility		
		A	B	Mean
	%	%	%	%
Crude Protein	30·06	85·0	88·0	86·5
Ether Extractives	19·54	91·5	91·6	91·6
Crude Fibre	10·78	13·3	20·5	16·9
Nitrogen-free Extractives	35·41	78·4	69·3	73·9
True Protein	26·95	86·1	85·6	85·9
Dry Matter	100·00	74·8	74·1	74·5
Organic Matter	95·79	77·9	76·2	77·1
Calculated Starch Equivalent (V number 97)		93·4	92·0	92·7
Calculated Protein Equivalent		24·4	24·8	24·6
Calculated Starch Equivalent (fibre factor)		90·1	88·5	89·3

The figures in Table VI were given by Woodman (1948) for English-made linseed cake.

TABLE VI.—WOODMAN'S FIGURES FOR LINSEED CAKE

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	33·2	85·8
Ether Extractives	10·7	91·6
Crude Fibre	10·2	49·5
Nitrogen-free Extractives	40·0	80·3

Starch Equivalent	83·3
Protein Equivalent	27·7

The local cake has a higher oil content than the English sample and this is the factor largely responsible for the increased starch equivalent of the East African sample of linseed cake. The only other significant difference between the two samples is the reduced digestibility of crude fibre in the local product. Whether this is a true digestibility coefficient or whether it is due to interaction of the concentrate with the basal diet is very difficult to say. It would seem that the whole question of feed interaction needs considerable study, particularly in view of the rather fibrous nature of many local fodders. Work on this is projected which, it is hoped, will throw some light on a rather difficult, but extremely important, subject. In the meantime there seems little one can do but accept the results obtained by use of the accepted procedures and, when judged on this basis, linseed cake is an extremely valuable concentrate, having a slightly wider nutritive ratio than its British counterpart.

LAND USAGE IN SEMI-ARID PARTS OF TANGANYIKA

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(*Received for publication on* 30*th November*, 1954)

Climatic and Other Factors

Data embodied in this article are based on results from experiments at Mpwapwa and other research centres as well as from general observations. It refers in particular to semi-arid deciduous thicket areas representative of Central Tanganyika, and the Veterinary Research Station at Mpwapwa is fairly representative of much of this area. This station is situated 3,500 ft. above sea level and receives an average annual rainfall of 26 in., which varies greatly in distribution and intensity from year to year. "Drought years", with low or erratic rainfall, are frequently experienced. The bulk of the rain falls between December and April, and there is generally one or more dry spells about February, which divides the rainy season into so-called "short rains" during December to January and "long rains" during March and April. There is, however, nothing definite about this pattern and some years the rain does not commence until January while during others the March-April rains may fail entirely. It also happens that the "February dry spell" might occur any time between the beginning of January and the end of March and it may vary to a great extent in duration. It has been stated most aptly that the only thing consistent about the rainy season is its inconsistency.

The uncertainty of rainfall is one of the main factors that make farming in these semi-arid areas hazardous, and it is for this reason that in the search for suitable pasture and crop species we have been forced to turn our attention to drought-resistant and quick-maturing types. I must emphasize the difficulty of laying down in detail a system that will suit every soil type and every farm, as naturally this will depend upon local requirements, marketing facilities, individual tastes and various other factors. In principle, however, the problem remains the same, and is basically one of sound land usage with proper cultivation, moisture conservation, and fertility improvement. The economics involved in turning bush into pasture without introducing cash crops are generally quoted as being insuperable on account of overhead expenditure being burdened by heavy clearing costs. Converting bush land into pasture via crops when suitable varieties are grown, however, seems a very satisfactory and economic way of land usage though, even under relatively dry conditions it appears desirable to use a semi-intensive farming system.

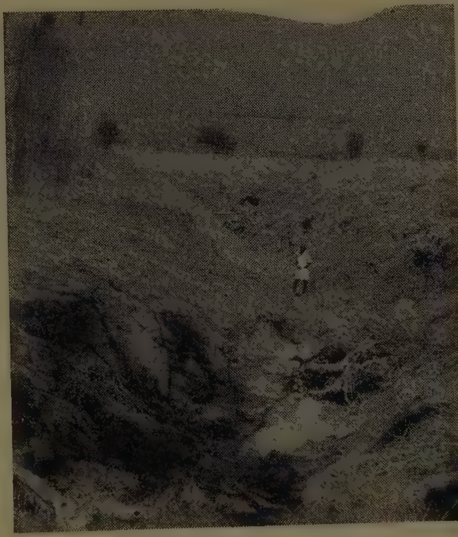

Fig. 1—Eroded gully cleared from bush thicket. It was stabilized with grass to serve as a discharge channel for adjacent fields. Mpwapwa, Central Tanganyika.

The following are some of the major problems which mitigate against farming progress:—

(*a*) Unreliable rainfall.

(*b*) Lack of responsibility towards the land. Tribal land tenure promotes exploitation of inherent fertility and fosters an attitude of irresponsibility towards the welfare of the soil. As long as new areas of bush exist which can be felled for opening up new fields the land is being used in an abusive manner to eke out a temporary existence until the top soil has been destroyed. It is most essential to cultivate a sense of responsibility towards the land. This is closely tied up with lack of farming knowledge and soil husbandry.

(*c*) The unavailability of seed of suitable grasses for leys to provide hay and grazing and to improve the level of soil fertility on fields which are too large for intensive manuring. Lack of suitable seed and planting techniques greatly hamper the development of improved farming methods and the introduction of leys as a regular feature on farms in various parts of the Territory.

(*d*) Heavy clearing costs and loss of inherent soil fertility before soil and moisture conservation measures are introduced, especially when yields are marginal due to fluctuating weather conditions.

(*e*) Poor communications and difficulties of marketing farm produce.

Bush Clearing Problems

Bush clearing under African farming conditions is generally done by felling and then placing the felled bushes in a dense layer over the surface of the soil. Where large trees are present only the thin branches are cut while the main stem and thick boughs are left. Towards the end of the dry season the branches are burnt and then, either before or after the first rains, grain seeds are planted in small holes dug by hand hoe in irregular fashion over the surface of the soil.

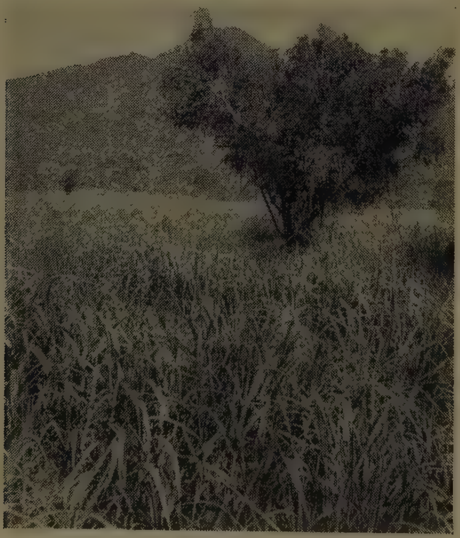

Fig. 2—Massive growth of elephant grass in the gully shown in Fig. 1.

Very much the same method of clearing was adopted during the early stages of bush clearing for establishment of pasture on the Mpwapwa Veterinary Reserve, and star grass roots were planted amongst the tree stumps after burning the bush. Only small areas were thoroughly cleared, cultivated, and planted to grain or silage crops.

During recent years mattocks have been used much more extensively in an attempt to obtain more thorough removal of stump and root growth. The beneficial effect of this treatment has been manifest in a number of ways and has resulted in striking improvement. It simplifies grazing control measures and makes it possible for mowing machines to be used for hay or silage production. It also allows much larger areas of land to be brought into profitable cultivation on a basis of rotation and the introduction of a system of ley farming and establishment of the better quality pastures.

The use of monkey winches, bulldozers and rooters facilitates to a very large extent the task of clearing, when the object is thorough root removal, and makes cultivation easier. Hormone bush killers such as 2, 4, 5-T are yielding most promising results, and it might bring about important modifications in clearing technique. Trees for shade and fodder are left wherever possible, particularly of species such as *Acacia spirocarpa* and *Acacia albida* which bear large crops of pods valuable for fodder. During the past few dry seasons considerable quantities of pods of these species have been used with very satisfactory results by adding about 10 per cent in concentrate mixtures for dairy cattle on the station. *Pithecolobium saman* (the Rain tree) shows great promise as an introduced fodder and shade tree, with a heavy yield of pods which become available at the height of the dry season.

Clearing costs vary very widely and might range from Sh. 50 to over Sh. 600 per acre depending upon different circumstances such as soil types, density and kind of vegetation, standard of work, methods or equipment used and efficiency of supervision. Under Central Province conditions in deciduous thicket vegetation, however, Sh. 200 per acre is a fair average figure for cost of thorough clearing to prepare the land for safe cultivation.

It is therefore advisable on newly cleared land to plan a cropping programme for two or three years to recover overhead expenditure on clearing, soil preparation, protection against erosion and pasture establishment. In an average year this can be recovered during the first year of cropping with yields of five to ten bags grain per acre. On fields where the fertility cannot be improved by intensive manuring and fertilizing, especially on land of marginal quality, cropping should not exceed three years before a pasture ley is established. The period of ley would be determined by various factors such as quality of pasture, recuperative power of the land, marketing conditions; and it may last from three to six years or more.

Preparation of Land for Cropping

One of the first essential measures to be taken is adequate dispersal of surplus storm water during sudden heavy downpours. Serious damage is caused when water rushes across the fields, especially on large fan slopes situated below steep hillsides. A very convenient way of doing this is to construct sloping contour banks, shedding their surplus water into gullies which form regular drainage lines—a very safe measure if these are protected by suitable grass growth. Thorough ridge cultivation, parallel to the sloping contour banks, would allow for better penetration of moisture, especially on soil which is not kept under cultivation continuously for long periods, and would further assist in gradual dispersion of excess water. If it is considered necessary to retain more moisture on the fields, these ridges could be "tied" to form small basins.

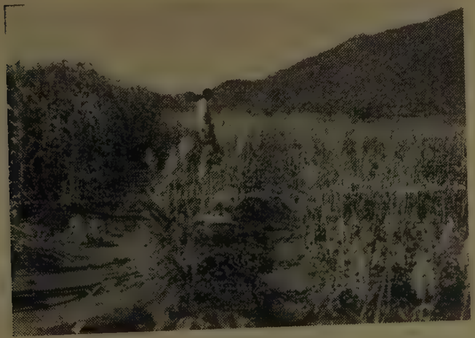

Fig. 3—Crops grown during the 1953/54 drought season. Left, Katumbili maize, yield 1,142 lb. grain per acre. Right, Dwarf Feterita Sorghum (ex U.S.A.), yield 1,059 lb. grain per acre. Mpwapwa, Tanganyika.

Adequate moisture penetration is a most important aspect in farming improvement in these areas where soil compaction is so prevalent. This can be done either by thorough cultivation to allow the water to get into the soil or by obtaining a satisfactory grass cover which binds the soil and reduces run-off to a very large extent. Other suitable vegetation types can also be used.

Crops

Grains

Sorghum is a most valuable grain crop for semi-arid regions with precarious and erratic rainfall. The introduction of dwarf quick-maturing varieties has been an excellent step forward and is likely to result in considerable advancement. Amongst the white-seeded kinds varieties such as Double Dwarf Shallu 6399-3-1, Dwarf Feterita and Hegari 750 have given satisfactory results. In spite of two severe successive drought seasons, yields of up to 1,279 lb. per acre have been obtained from D.D. Shallu and up to 1,806 lb. from R.S. tall Sorghum. The Sorghum plants resist long drought spells with little apparent adverse effect and even under most unfavourable conditions they produce a crop of sorts. Out of a large number of Sorghum varieties tried, a high proportion gave very satisfactory results.

Bulrush Millet (*Pennisetum typhodium*) is a very hardy and drought-resistant crop. In some areas it has been a great standby in drought years. Unfortunately, however, the variety being commonly grown at present in Central Tanganyika takes a very long period to mature and the introduction of quick-maturing varieties is most desirable.

Slow-maturing varieties of maize are most undesirable although satisfactory crops are sometimes obtained during years of good rainfall with favourable distribution. Relatively quick-maturing yellow varieties and Katumbili have given more satisfactory results, but too much reliance on maize with inadequate plantings of Sorghum seems to be one factor that has been responsible for serious food shortages during drought years.

With thorough ridge cultivations and consequent moisture conservation yields of 1,142 lb. have been obtained from Katumbili at Mpwapwa during the past drought year.

Pulses

Cowpeas are generally most satisfactory in semi-arid areas of Central Tanganyika and may yield fair crops even when planted late in the season, say up to March.

Groundnuts are most popular in certain areas of Central Tanganyika and are grown fairly extensively by African cultivators. Apart from being an excellent food it is also valuable as a cash crop.

Beans, Soya beans, and Fiwi (*Dolichos lab lab*) are also grown extensively with moderate and varying degrees of success in different localities. On the whole, however, yields are not very high.

A number of varieties of velvet beans, originally obtained from Ukiriguru and Southern Rhodesia, tried at Mpwapwa since 1946, have proved most promising for this area, and during the past drought years yields of up to 1,508 lb. per acre of shelled seeds have been obtained. Unfortunately velvet beans are not considered to be suitable for human consumption and their main value is therefore likely to lie in their use as local stock food, for cash sale and for soil improvement. Unlike some of the other legume crops such as sunn hemp which are used for manure, velvet bean with its prolific growth provides an excellent cover for the soil and suppresses weed growth. If a market could be developed it would be an excellent crop for these conditions. It is interesting to note in the Dar es Salaam Produce Exchange report for the week ending 25th September, 1954, that 50 tons of velvet beans were sold at Sh. 400 and Sh. 380 per ton.

Cash Crops.

Castor is being grown most commonly as a cash crop and is convenient and easy to handle. One very unsatisfactory aspect about its production, however, is that it is planted across drainage lines which in the normal course of events should be left uncultivated. Where planted on bare flat eroded slopes it does not grow well and dies off during drought weather. This plant could be grown successfully if planted on land properly cultivated and ridged so that more moisture can be conserved.

Crops in the Rotation

It appears to be uneconomic to establish pasture on land cleared from bush before two or three crops have been grown, and in clearing and preparing the land the following procedure should be followed:—

Felling should be followed by thorough mattocking to remove all stumps and roots making the land safe for cultivation. The brush can either be piled and burnt, or placed in adjacent gullies to slow down the rush of water and to encourage better grass growth preventing further erosion. Grass growth in gullies cleared from bush thicket is generally magnificient due to an accumulation of fertile soil and increased moisture, so that it seems well worth while clearing all gullies when clearing is done on the slopes. Furthermore, bush-covered gullies are most undesirable near cultivated fields, as they harbour vermin. They provide a nesting and resting place for grain birds as well as cover for predatory animals such as wild pig, baboons and bush buck.

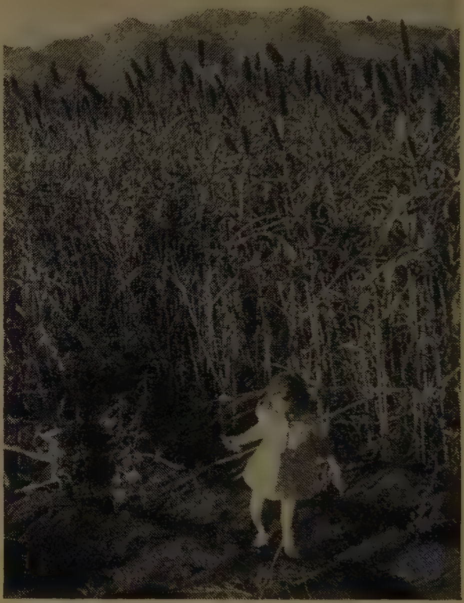

Fig. 4—Sugar Drip Sorgo (ex U.S.A.) grown during the 1953/54 drought. It yields 1,164 lb. grain per acre, and because of the sweetness of the stems it is an ideal variety for silage and stover. Mpwapwa, Central Tanganyika.

After clearing the bush, sloping contour banks are made to drain surplus water from the slopes into the gullies, particular attention being paid to the top ones to prevent unwanted flood water from entering and flowing over the fields. The fields are then cultivated and crops planted on ridges following the sloping contours, thereby introducing an additional safety measure against erosion. If considered necessary, the ridges could also be "tied" to establish a series of basins to hold more water, while the risk of breakages and erosion damage are reduced to a minimum and can only effect one ridge at a time or one contour belt. The accumulation of a large volume of water is dangerous in that one breakage might result in gully-washing down a field.

The exact sequence of crops in the rotation will depend upon various factors, though as a general guidance it could be based on the following pattern:—

First Year.—Grain crop: (Sorghum or Bulrush Millet or Maize).

Second Year.—Grain crop: (Sorghum or Bulrush Millet or Maize).

Third year.—Legume: (Groundnuts or Cowpeas or Velvet bean or beans or Soya beans).

Fourth year.—Short growing grain or legume crop (Dwarf Sorghum, Cowpeas, beans or Soya beans) interplanted with grass.

LEYS

In the search for suitable plants for pasture leys many hundreds of species have been propagated under trial. A considerable number have shown promise, but unfortunately most of them could not be readily established from seed. Propagation from roots is unsatisfactory on account of expense and high labour demands at a time when ordinary farm and crop work must take priority.

The duration of a grass ley will also depend upon a number of factors, for example the quality of the pasture, the nature of the soil, farming policy, and local requirements. In fertile valley soil, where fertility can be kept up by manuring and fertilizing, grass leys might barely come into the picture, whereas on marginal land the period of cropping might be very short in relation to the length of time it is under grass. On such fields the primary object of bringing the land under cultivation might well be renovation of the pasture by breaking up the soil to obtain better water penetration.

The production of crops and the propagation of pasture leys are most dependable and interlocked facets of land usage. Without proper care of the one the other invariably suffers severely. Breaking up the hard soil surfaces to allow maximum penetration and absorption of water is essential for grass establishment and maximum growth, and it is better to get grass established after cultivating for a few years than to hope for satisfactory growth on bare eroded soil which generally is almost impenetrable to water and where as much as 80 per cent or more of the rainfall might run off during heavy showers. From an economic farming angle this course is most advantageous, because maximum production can be expected when the land is cleared and cultivated for crop production before establishing pastures.

A most important point, however, is that the grass for the pasture ley should be established with the last crop, in order to save time and to obviate the necessity of cultivating the land again during the season after the crop. Dwarf Sorghums, cowpeas, beans, Soya beans, barley and other crops are very suitable for this purpose, as they do not smother the grass seedlings as easily as maize or tall Sorghum by overshading. Some of these species are also beneficial nurse crops which give needed protection to the young grass seedlings.

Suitable Grasses

Cynodon plectostachyum (star grass) has for a very long period been recognized to be one of the most suitabe grasses for semi-arid Central Tanganyika and Staples has reported fully on a number of local varieties in the 1933-38 Annual Reports of the Department of Veterinary Science and Animal Husbandry. The accepted method in the past has been to establish star grass from roots. Due to its spreading habit, it is relatively easily propagated in this way and it has almost become standard practice. The main disadvantage of this method, however, is that planting time is limited to a relatively small number of days when the soil is wet and that coincides with the time of the season when pressure of work on crop production and general farming activities is at its height. Apart from such inconveniences, it naturally severely restricts the area that can be planted during any one season. It is for this reason that grass planting on an ordinary farm never progresses beyond the planning and "conversation" stage.

In spite of the very low viability of star grass seed and disadvantages of two successive drought years, most promising results have been obtained from star grass seeding during the past two seasons. A field established in January, 1953, has not only produced an excellent cover but has provided good hay crops and grazing. This has in fact been so striking that I consider it worth while for every farmer to make an effort to harvest his own supply of star grass seed especially seeing that this can be done in June or July when the pressure of normal farm work begins to decrease. An added advantage is that star grass has a small heavy smooth seed without hairs or awns and can easily be planted by machine. It is most noticeable that fields which are mown or closely grazed about April produce an abundance of flowering culms very shortly afterwards and it can be harvested most conveniently after the rains are over when the seeds ripen. This is also the case with Rhodes grass, African foxtail and some other species.

Star grass is ideal for anti-soil erosion work and can be established beneficially along gully banks to reduce erosion and to build the soil. Its amazing capacity to reduce run-off and erosion has been evident from experiments carried out at Mpwapwa and described by R. R. Staples in annual reports of the Department of Veterinary Science and Animal Husbandry between 1933 and 1938 and by H. J. van Rensburg in a recent report entitled "Run-off and Soil Erosion Tests", Mpwapwa, Central Tanganyika. (*vide* this issue, p. 228.)

Chloris gayana (Rhodes grass) is generally considered to be rather marginal in these semi-arid areas though it was noticed that one variety, originally collected from the Iringa district about 1937, held its own very well in a fodder plant collection nursery established at Mpwapwa. In 1949 it was transferred for special observation and multiplication. In 1950-51 it was again extended and did so well that in 1952 it was established from seed on field scale. These sowings were further extended in 1953 and 1954 with most encouraging results, in spite of two most adverse drought years. Apart from excellent growth they also produced a very satisfactory cover that suppressed weed growth to a very large extent compared with adjacent fields of *Brachiaria brizantha, Cenchrus ciliaris* and *Setaria sphacelata.* The latter died out almost entirely during the first drought season.

Very encouraging reports have also been received from Nyasaland and Kenya where this variety of Rhodes grass was grown for comparison with others.

It would seem that Rhodes grass is an ideal species for short duration grass leys on fields which go back to crops at regular intervals as it can be ploughed out with ease.

Commercial seed supplies of Rhodes grass have been well developed and it is generally readily available in bulk on the market. The problem of selecting and developing the most suitable variety, however, warrants further attention.

Similarly to star grass, late growing season cutting, about April or May, brings on a flush of seedheads which are easily harvested in June or July.

Cenchrus ciliaris (African foxtail) is an excellent drought-resistant pasture and hay grass and it is capable of remaining green until the dry season is well advanced. A big disadvantage is its tussocky growth habit which does not provide a ground cover like star grass and Rhodes grass. This tussocky growth habit is also noticeable with some other species such as *Brachiaria brizantha, Panicum maximum* and *Setaria sphacelata.* For this reason mixed pastures seem to be desirable in these areas. A number of *Cenchrus ciliaris* varieties developed at Lubaga in the Lake Province are semi-prostrate in habit but unfortunately they do not readily root at the nodes. If established together with star grass and Rhodes grass these species would tend to cover the bare spaces amongst the tussocks of African foxtail and with suitable management a good cover can be maintained.

Panicum maximum (Guinea grass), *Panicum makarikariensis, Urochloa pullulans* and *Dicanthium papillosum* all of which are still under trial show some promise and it might be possible to develop some of these for seeding under local conditions. For this purpose a short, leafy variety of *Panicum maximum* is being selected as it seems more desirable than the tall stalky and coarse varieties which are abundant locally, though even the latter varieties can be used to very good advantage in mixed pastures for grazing and silage. The short, leafy varieties would lend themselves better to hay making and mechanized seed production. A leafy, palatable variety of *Brachiaria brizantha* with a large seed which can easily be handled was unforunately disappointing in the trial plots though it would be well worth establishing in mixtures, especially under more favourable climatic conditions. *Setaria sphacelata* did well during favourable rainy seasons but could not survive two successive drought years. On fields where four successive maize crops were grown previously, all the *Setaria sphacelata* plants died off, where cropped for three years previously a few plants survived and on a relatively fertile field where only one crop was grown since the bush was cleared a large percentage of *Setaria sphacelata* plants survived. On the whole, however, this species seems to require more favourable conditions than those prevailing in semi-arid Central Tanganyika. A field of *Pennisetum purpureum* (Elephant grass) planted from roots, stems and seed grew very satisfactorily in spite of the drought seasons and has remained green practically throughout the year. Planted in some eroded gullies it grew remarkably well and yielded over 38 tons of green fodder per acre during the 1953-54 drought season. On the whole, however, star grass is a more satisfactory soil binder on eroded land in dry areas and under these conditions also gives a large amount of grazing. It grows vigorously in gullies due to the accumulation of fertile soil particles and more moisture. It is necessary, however, to remove dense bush growth from the gullies as the grass does not grow in dense bush and furthermore, bush is less effective against erosion than a good gsass coves.

Suitable Legumes

Glycine javanica, a local trailing legume shows considerable promise as a fodder plant and can be established from seed fairly readily, either alone or in combination with grasses. It is palatable and can be grazed or cut with other herbage for hay and silage. Seed supplies are limited but can be harvested by hand where it climbs over hedges and bushes. Under these conditions seeding is prolific.

Lucerne grows very well under irrigation on fertile soil, particularly during the cool season. Yields of over 50 tons green fodder per acre per annum in six to eight cuttings are obtained. Lucerne planted by itself as well as mixed with grass seed in January, 1953, and March, 1954, has survived two severe successive drought seasons indicating that it might be possible to establish lucerne with grass seed mixtures to improve the quality of pastures even if it only survives for a limited period. A small plot established in January, 1953, yielded 1,245 lb. per acre the first season and 930 lb. per acre in 1954.

Velvet beans have given most encouraging results under Central Province conditions and even during the past two drought years, excellent yields have been obtained. Seed samples of two varieties, one white and one black were obtained from the Ukiriguru Agricultural Station in 1946 and four varieties from the Salisbury Agricultural Experiment Station, Southern Rhodesia in 1948. These were "Somerset No. 52"; "Jubilack No. 54" and "No. 77". All six varieties did well though the quicker-maturing ones such as "Somerset" and "Local white" were superior during drought years. During 1953 and 1954 yields of up to 12,112 lb. silage material per acre and 1,508 lb. of dried shelled seed per acre were obtained. It seems to be a promising cash crop for this area if the seed can be marketed; and as it contains up to 27 per cent protein it can be advantageously used in dairy rations while the plant itself is most useful for grazing, hay and silage. It provides cover, protects and improves the soil, as well as helping to smother annual weeds. On the whole it seems to be relatively free from pests and diseases.

Cowpea is a very good "stand-by" crop in semi-arid areas. Unfortunately it does not yield heavily and is frequently attacked by insects especially when planted early; though on the other hand it seldom fails entirely. Furthermore, its planting can be delayed until most other crops have been planted and satisfactory yields have been obtained from fields planted near the end of March. It is also useful for interplanting with other crops when germination is poor. During the past two drought years, yields of up to 360 lb. per acre have been obtained from fields which were planted rather late.

In 1953 and 1954, 15 varieties of Soya beans, both local and imported from the United States of America were established in test plots. On the whole these were disappointing though some varieties gave promising yields and warrant further testing.

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NUTRITIVE VALUE OF COFFEE HULLS

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(*Received for publication on 5th October*, 1954)

The determination of the feeding value of dried coffee hulls followed the standard pattern of calculating their digestible protein equivalent and starch equivalent from the results of digestibility trials conducted with two Masai-type wethers. The experimental technique employed was identical to that used for the sunflower trial previously reported (Rogerson, 1955) and the trial was commenced after a preliminary feeding period of fourteen days. The coffee hulls were fed together with an oat hay of determined digestibility, the rations fed to the two sheep being 300 g. oat hay + 200 g. coffee hulls daily. The coffee hulls appeared to be quite palatable, as evidence of which no feed residues were obtained from either sheep.

Analytical methods were identical to those employed in the previous trial, nitrogen being determined by micro-distillation (Markham) after the usual Kjeldahl digestion. Ether extractives, crude fibre and true protein were all estimated by approved techniques.

The oat hay used as the basal diet had the composition and nutritive value given in Table I.

TABLE I.—OAT HAY BASAL DIET

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	12·22	68·1
Ether Extractives ..	1·11	7·7
Crude Fibre	29·30	69·0
Nitrogen-free Extractives	47·10	73·2
Ture Protein	9·71	61·0
Dry Matter	100·00	70·3
Organic Matter ..	89·73	70·3

Calculated Starch Equivalent	47·1
Calculated Protein Equivalent	7·1

Results

Sheep A.—Food ingested—2,508 g. hay + 1,704 g. coffee hulls (D.M. basis).

Dry weight fæces 1,804 g.

Fæcal crude protein (wet analysis) 249.8 g.

Sheep B.—Food ingested—2,508 g. hay + 1,704 g. coffee hulls (D.M. basis).

Dry weight fæces 1,764 g.

Fæcal crude protein (wet analysis) 245.8 g.

Assuming the hay portion of the ration to be digested as when fed alone, then the nutritive value of the coffee hulls can be assessed as in Table II.

TABLE II.—NUTRITIVE VALUE OF COFFEE HULLS

	Dry Matter Analysis	Digestibility		
		A	B	Mean
	%	%	%	%
Crude Protein	10·17	12·3	14·6	13·5
Ether Extractives ..	1·58	94·1	92·9	93·5
Crude Fibre..	35·46	22·7	29·4	26·1
Nitrogen-free Extractives	45·68	47·6	49·7	48·7
True Protein	7·29	—	—	—
Dry Matter..	100·00	37·9	40·2	39·1
Organic Matter	92·89	36·6	39·8	38·2
Calculated Starch Equivalent		13·3	16·8	15·1
Calculated Protein Equivalant		0·6	0·7	0·7

It will be noted that the hay used as the basal diet was of extremely high feeding value and it is conceivable that this reflected adversely on the digestibility of the less nutritious coffee hulls. But in mentioning this point, it should also be noted that there is little experimental evidence available concerning the effect of more nutritious basal rations on the digestibility of added supplements. It might, of course, be suggested that the high quality hay promotes a more active rumenal flora which possibly tended to enhance rather than decrease the digestibility of the added coffee hulls.

It was thought advisable, therefore, to re-determine the feeding value of coffee hulls. Another sample of hulls was obtained, from a completely different source. Hay, from Kikuyu grass (*Pennesetum clandestinum*), of average feeding value was in this case used as the basal ration and the trial was conducted with two Merino type wethers. The experimental technique and analytical procedures were, of course, identical to those described in the first part of this paper.

The hay used as the basal diet had the composition and nutritive value given in Table III.

TABLE III.—KIKUYU GRASS HAY BASAL DIET

	Dry Matter Analysis	Digestibility
	%	%
Crude Protein	12·07	53·2
Ether Extractives	0·78	Negative
Crude Fibre	35·24	67·1
Nitrogen-free Extractives	41·42	49·8
True Protein	9·71	44·0
Dry Matter	100·00	54·4
Organic Matter	89·51	56·0

Calculated Starch Equivalent	29·9
Calculated Protein Equivalent	5·4

Results

Sheep A.—Food ingested—2,379 g. hay + 1,636 g. coffee hulls (D.M. Basis).

Dry weight fæces 2,035 g.

Fæcal crude protein (wet analysis) 276.2 g.

Sheep B.—Food ingested—2,379 g. hay + 1,636 g. coffee hulls (D.M. basis).

Dry weight fæces 2,012 g.

Fæcal crude protein (wet analysis) 274.1 g.

Assuming the hay portion of the ration to be digested as above, then the nutritive value of the coffee hulls can be assessed as in Table IV.

The second sample of coffee hulls had a somewhat lower crude fibre figure and, perhaps rather surprisingly, a lower crude protein content, and its percentage digestibility was also lower than in the former trial. The greatest variation between the two samples, however, lies in the ether extractive digestibility coefficient. Digestibility coefficients of this particular fraction are quite often suspect and difficult to interpret, especially so when the quantity present in the basal ration falls to such a low figure as was present in the Kikuyu grass hay sample—0.78 per cent. The figure, however, of 2.02 per cent fat in the coffee hulls is sufficiently low to cause no great error in the final calculation of the starch equivalent, even should the digestibility coefficient for this constituent be grossly wrong.

TABLE IV.—NUTRITIVE VALUE OF COFFEE HULLS (2ND TRIAL)

	Dry Matter Analysis	Digestibility		
		A	B	Mean
	%	%	%	%
Crude Protein	9·25	6·3	7·7	7·0
Ether Extractives	2·02	10·3	15·5	12·9
Crude Fibre	29·74	26·7	32·6	29·6
Nitrogen-free Extractives	51·46	51·2	51·9	51·6
True Protein	7·72	6·9	9·2	8·1
Dry Matter	100·00	41·9	43·3	42·6
Organic Matter	92·47	40·6	43·2	41·9
Calculated Starch Equivalent		18·0	20·4	19·2
Calculated Protein Equivalent		0·6	0·7	0·7

In conclusion, it may safely be said that coffee hulls, in spite of their apparent palatability, are hardly to be classed as a useful basic feed and certainly cannot be regarded as a concentrate supplement. The digestible protein present in the coffee hulls is very low, while the starch equivalent value does not exceed that of fairly poor quality hay.

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SPECIES OF TILAPIA IN EAST AFRICAN DAMS, WITH A KEY FOR THEIR IDENTIFICATION

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In East Africa there are at least 20 species of fish belonging to the genus *Tilapia*. It seems that certain species were at one time restricted to particular areas; for example, the "ngege", *Tilapia esculenta,* and the "mbiru", *T. variabilis,* occurred, as far as we know, only in the Lake Victoria catchment area and in Lake Kyoga. However, these and other species have been used for stocking dams throughout the three territories, with the result that their earlier geographical distribution has been greatly altered, and several species which were restricted in their distribution are now widely distributed.

It is, perhaps, rather unfortunate that certain species should have been used rather extensively for stocking purposes before more was known about these fish, as it is now evident that some are better able to establish themselves in small bodies of water than are others. In some cases the unsuccessful stocking of dams has led to the opinion that *Tilapia* are not suitable fish with which to stock dams. Two issues need to be kept clearly separate; first, whether any particular dam is potentially fertile, and secondly, after assessing the suitability of the conditions obtaining in a dam, to decide which species of *Tilapia* is most likely to do well in it.

Considerations regarding the fertility of ponds and dams and their hydrological suitability for fish culture fall outside the scope of this paper.

The realization that the different species of *Tilapia* possess different feeding and breeding habits, and that they differ in their ability to establish themselves in small bodies of water, has led to more interest being taken in the specific determination of these various species, and requests to identify *Tilapia* are frequently sent to the territorial departments concerned with Fisheries, to the Lake Victoria Fisheries Service and to the East African Fisheries Research Organization. It has not always been possible to answer these requests satisfactorily, as the specific identification of these fish is extremely difficult. A special effort has, therefore, been made to produce some notes and a key that will make it possible to identify most of these fish with a reasonable degree of certainty.

Four species of *Tilapia,* though they occur in East African dams, are not considered in this paper; they are uncommon and have a restricted distribution. Their inclusion would make the present key extremely complicated and difficult to interpret, so it has been decided to omit them altogether. These species are, however, described in a separate paper [*see* Lowe, 1955].

Tilapia belongs to the family Cichlidæ; characteristically members of this family have a long spiny dorsal fin, a single nostril on each side of the snout, and an interrupted lateral line which may be in either two or three parts (*see* Fig. 1).

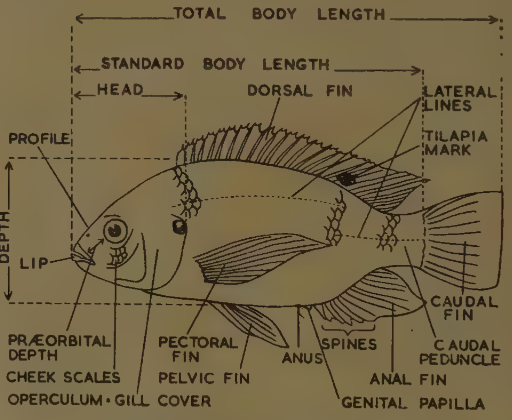

Fig. 1—"Tilapia" showing the parts of the body examined to determine the species.

In East Africa fish belonging to the genus *Tilapia* must, in the first place, be distinguished from another widely distributed and common Cichlid genus, *Haplochromis*. It is sometimes difficult to distinguish between small individuals belonging to these two genera. However, there are three characters by which they can be told apart. *Tilapia* have cycloid scales; the exposed part of these scales is smooth, whereas *Haplochromis* have ctenoid scales which are rough. A *Haplochromis* feels rough if stroked from tail to head. Young *Tilapia* have a black spot near the hind end of the dorsal fin which distinguishes them from *Haplochromis*; this black spot, "the Tilapia mark", may be retained throughout life by certain species. *Haplochromis* do not have this black spot on the dorsal fin at any age. Adult *Haplochromis* often have brightly coloured "eye-spots" on the anal fin; there are never found in *Tilapia.*

Haplochromis do not grow asl arge as *Tilapia,* so any Cichlid fish weighing more than three-quarters of a pound can, in almost all cases, be considered to be a *Tilapia.*

The different species of *Tilapia* can be recognized by slight differences in their shape and by the number of their fin rays, scales, gill rakers and teeth. These features are illustrated in Fig. 1. When comparing fish which may belong to different species, it is advisable to select individuals of the same size whenever possible.

Tilapia species may also be distinguished by various biological characters, such as their colour patterns, particularly when breeding, their behaviour, the shape of the nest and the colour and size of the eggs.

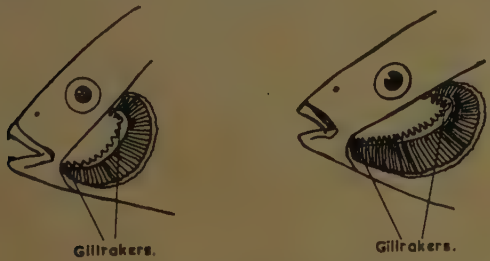

Fig. 2—Heads of "Tilapia" with gill cover removed to expose the gills. Only the gill rakers on the lower part of the arch are counted; the specimen on the left has ten gill rakers, and that on the right 18 gill rakers.

Among the *Tilapia* now in dams in East Africa only two species, *T. melanopleura* and *T. zillii,* do not brood their eggs and young in the mouth; both males and females, however, "guard" their eggs and young in a nest, and both sexes develop a bright breeding dress. In all the other species occurring in East Africa eggs and young are brooded in the mouth by the female, which retains the rather drab colour of the non-breeding fish. The male of the brooding species develops a highly coloured breeding dress which is often distinctive for the species.

The shape of nests seen on the bottom of a pond may indicate which species are present. The nests made by *T. melanopleura* and *T. zillii* are groups of 5–10 small holes on the sloping banks of the pond, generally near the water surface. Nests of the other species are generally circular craters, slightly larger than the length of the males, and are found on the bottom of the pond. *T. macrochir* makes a very distinctive nest with grooves radiating from a central crater.

Female *T. melanopleura* may be distinguished from female *T. zillii* by the colour of their eggs. *T. melanopleura* has yellow eggs, whereas *T. zillii* has green eggs. The only other species which has green eggs is *T. galilæa.* The colour of the eggs can be observed in ripening ovaries and after they have been shed.

Both *T. melanopleura* and *T. zillii* eat water plants, and may in small ponds keep such weeds under control. Some plants are preferred to others; water lilies are not eaten, and *Ceratophyllum* (hornwort) is not eaten if other plants are available. *T. zillii* can be fed on chopped grass.

The other species of *Tilapia* are mainly algal feeders. In lakes they live mainly on phytoplankton, microscopic algæ floating in the water. In ponds there is usually little phytoplankton so they may not do well in ponds where their food is restricted to algæ growing on other plants or on the bottom. Remains of insect larvæ, tadpoles, and even fry of their own species have been found in the stomachs of various species of *Tilapia* taken from ponds.

Mature female *Tilapia* may lay batches of eggs every few weeks and, under tropical conditions, may spawn continuously throughout the year. However, where there is a cold or very dry season spawning may be less frequent during this season. All the species of *Tilapia* grown in ponds have shown a tendency to breed at a small size and to breed frequently. A discussion on the possible reasons and remedies for this is outside the scope of this paper, but "mono-sex" culture, advocated by Copley, Brown and van Someren in Kenya [2 and 3] can help to overcome the slow growth rate of mature *Tilapia.* Mono-sex culture can only be carried out if the sex of the fry when about 5–7 cm. long can be determined. In *T. nigra* Brown and van Someren [2] have found that the males grow faster than females; this occurs even among the very small fish, so that, from batches of young spawned at one time, males may be separated from females by their length when about 7 cm. long. In many of the East African *Tilapias,* however, the two sexes grow at the same rate.

In some species it is possible to tell the sex from the appearance of the genital papilla, which lies immediately behind the anus [*see* Fig. 1]. In the male the papilla is conical with only one aperture near the tip, this is a combined ureter and genital opening. In the female the papilla is broader and has two apertures, the oviduct, which opens as a transverse slit across the papilla, and the ureter, which has a small opening behind the oviduct [*see* Fig. 3].

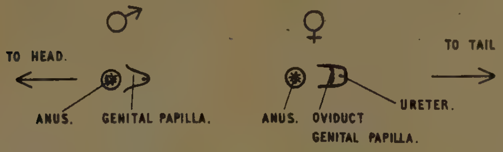

Fig. 3—Diagrammatic representation of the genital papilla of male and female "Tilapia".

As has already been pointed out the specific identification of the several species of *Tilapia* is extremely difficult. Morphologically these fish are very similar, although, as already indicated, their habits and physiology differ to a considerable extent. The key that follows is an attempt to produce means whereby the 10 commoner species occurring in East Africa can be distinguished one from another. As it is not possible to do this on morphological characters alone, it has been necessary to include descriptions of colour patterns. Colour patterns are not really satisfactory specific characters as they are liable to subjective interpretations, but they do help, particularly if the fish can be observed alive and when free swimming.

In the key, contrasting characters are presented under a number; for example, if the fish has less than 12 gill rakers proceed to (2); but if it has more than 14 gill rakers, proceed direct to (3), etc. The characters are generally arranged in order from the most distinctive to the least distinctive; if a character is particularly distinctive it is printed in italics.

Some of the terms used in the key need to be defined. The "standard body length" from tip of snout to base of tail fin is the recognized measurement used when considering the proportion of head size or body depth to length of fish, not the "total body length" which includes the tail fin.

Both dorsal and anal fins are supported by "spiny" rays anteriorly and "soft" rays posteriorly; as the soft rays branch near their tips they must be counted at the base of the fin.

The "scales of the lateral line series" are those scales which bear the lateral line pores, and are counted from the start of the lateral line, immediately above the gill cover, along the upper lateral line, then, without counting, down diagonally to the lower lateral line as shown in Fig. 1, the count being continued along the lower lateral line to the base of the tail fin. Scales from the "lateral line to the anterior end of the dorsal fin" are counted diagonally as indicated in Fig. 1, excluding the lateral line itself. Scales "around the caudal peduncle" are counted diagonally right round, and those "over top of caudal peduncle" are counted from lateral line to lateral line over the top of the peduncle, excluding the lateral line scales. The count for the number of scales on the cheek is made on those scales situated vertically below the eye.

To count the gill rakers it is necessary to cut the membrane joining the gill covers below the head and to lift the bony operculum. This exposes the first gill arch and its gill rakers which lie immediately opposite to the gill filaments [Fig. 2]. Only the gill rakers on the lower part of the anterior arch are counted.

Tilapia have several rows of short, generally two-cusped, teeth in the upper and lower jaw. They also have pharyngeal teeth in the throat. These "pharyngeal teeth" form part of the mechanism which enables fish to swallow their food (Greenwood, 1953). The pharyngeal teeth vary from species to species and provide in some cases a useful diagnostic character, but this feature has been excluded from the present key, except in one case. To examine these teeth it is necessary to kill the fish and extract the tooth-bearing lower pharyngeal bone. This lies on the floor of the throat between the gill arches at the entrance to the oesophagus. The size of the pharyngeal teeth, their distribution on the pharyngeal bone and the extent and shape of the toothed area are important diagnostic characters, but specific identification by this character should be left to the specialist.

FIELD KEY TO SPECIES OF TILAPIA

(1) 8–12 gill rakers on lower part of anterior gill arch (*see* Group (2)).

14 or more gill rakers on lower part of anterior gill arch (*see* Group (3)).

(2) (*a*) *Adult.—Colour*: Predominantly slatey grey, centres of scales dark; lower flanks may be pink; ventral surface and pelvic and anal fins very dark grey; lips grey; dorsal fin grey, sometimes with peacock blue spots, without

orange edge; tail grey or with *upper half dark grey, lower half lighter grey or pink*. Breeding fish darker, slightly iridescent, ventral surface black and above this a red band extending to lower half of tail fin. "*Tilapia* mark" generally retained in adult, but sometimes indefinite, black, slightly elongated at right angles to axis of fin rays and extending from 1st to 3rd soft ray, surrounded by colourless area; opercular spot not very definite. Dorsal outline of body generally highest in front of dorsal fin. Ovaries yellow.

T. melanopleura (Dumeril.

Young *T. melanopleura* (circ. 5 cm.). *Colour*: Whiteish or slatey, *pelvic fins orange*, rather pointed and generally reaching to anus; hind end of dorsal fin with the "*Tilapia* mark" elongated slightly and at right angles to axis of fin rays, enclosed in clear area, and followed posteriorly by three or four black bars alternating with yellow. Opercular spot not very definite; tail without vertical stripes.

(*b*) *Adult.—Colour*: Brownish with irridescent, colourful peacock sheen; lips light green. Dorsal, anal and tail fins brownish with yellow spots and often a narrow orange edge to dorsal and tail fins. Breeding fish colours greatly intensified very iridescent, peacock green spots on head and often a light green line continuing the line of the lower lip to the hind edge of the operculum, yellow spots on vertical fins, ventral surface black surmounted by deep crimson on lower sides of body. "*Tilapia* mark" very large and definite and retained in adult as an almost circular, black blob extending from last dorsal spine to fourth soft ray, almost surrounded by yellow area; opercular spot black and definite. Dorsal outline of body highest behind origin of dorsal fin. Ovaries green.

T. zillii (Gervais).

Young *T. zillii* (circ. 5 cm.). General colour brownish, often with faint orange tips to dorsal and caudal fins; *pelvic fins colourless*, less pointed and shorter than in *T. melanopleura* and not reaching to anus. "*Tilapia* mark" outstanding black blob slightly drawn out along the axis of the rays, surrounded by a yellow area; opercular spot more definite than in *T. melanopleura;* traces of dark vertical stripes on tail.

(3) (*a*) Four or more anal fin spines (*see* Group (4)).

(*b*) Three anal fin spines (*see* Group (5)).

(*N.B.*—In (5) an occasional specimen may have four spines.)

(4) *Body colour*: Not spotted, greenish, dark green on back, whiteish grey on belly; breeding male black. *Scales*: Lateral line series with 32 scales; *gill rakers* 15–20.

T. nigra (Günther).

(5) (*a*) Tail fin with *well marked vertical black stripes* throughout life (*see* Group (6).

(*b*) Tail fin with spots or blotches of pigment throughout life (*see* Group (7)).

(*c*) Tail fin immaculate throughout life; i.e. without any blotches, stripes, or other marking; body colour light grey with vertical black stripes. Body rather deep. Pharyngeal teeth very fine and forming a dense velvet on lower pharyngeal bone.

T. galilæa (Artedi).

(6) Anal fin with three spines and 8–11 soft rays. *Body colour*: Brownish grey, sometimes with vertical stripes, not spotted. Breeding male develops black ventral surface, black pelvic and anal fins and reddish colour on head and flanks. *Scales*: Lateral line series 30–33. *Gill rakers*: 19–28.

T. nilotica (Linn).

(7) (*a*) Dorsal profile of head becoming concave and jaws elongated in large fish, particularly in males. Mouth appears large and wide; lips fairly well developed; jaw teeth in wide bands; males generally larger than females. *Gill rakers*: Generally less than 20. Originally confined to the Eastward flowing river systems (*see* Group (8)).

(*b*) Dorsal profile of head straight and remaining so even in large fish of both sexes; mouth appears small, lips not well developed and jaw teeth in narrow bands. Females may attain same size as males (except in some *T. leucosticta*). *Gill rakers*: Generally more than 20 (*see* Group (9)).

(*c*) Dorsal profile of head very convex; broad head; red flecks on head; 23–25 gill rakers. A central Africa species introduced into, and rare in, East Africa.

T. macrochir (Boulenger).

(8) *Colour*: Variable, from dark brown grey to silver grey sometimes with about six vertical dark bars. *Scales*: Lateral line series 29–32

(rarely 33). *Dorsal fin* with 27–29 (rarely 26 or 30) spiny and soft rays. *Anal fin* with 12–15 spiny and soft rays. *Gill rakers* 14–19 (rarely 20). Outer teeth in jaws of mature males are unicuspid.

T. mossambica (Peters).

(9) (*a*) *Colour*: Dark green or greenish fawn or grey; *general appearance spotty* due to centre of scales being lighter in colour than the periphery; light yellowish spots on dorsal anal and caudal fins. *Lower lip white*. Genital papilla well developed throughout life. Breeding males dark green, almost black, with light blue spots on dorsal, caudal and anal fins, iris of eye bright orange, crossed by black stripe including the pupil. Genital papilla small and white; lips greenish white. *Scales*: In lateral line series 30–31. Three or four scales between lateral line and anterior end of dorsal fin; 16–18 round caudal peduncle. Males often larger than females.

T. leucosticta (Trewavas).

Young *T. leucosticta* (5 cm.). "*Tilapia* mark" present, but not very well defined and followed by light spots on grey background on hind end of dorsal fin. *Colour*: Olive greenish grey, with 10–12 thin vertical dark stripes extending from dorsal fin to belly.

(*b*) *Colour*: Non-breeding fish and females greenish fawn or grey, *but* uniform, not spotty, sometimes centre of scales slightly darker than the periphery; lips uniform with body colour. Iris brownish and pupil large. *Dorsal fin with orange tips throughout life*. Breeding males blueish green, with bright orange edge to dorsal and caudal fins. An orange genital tassel, often several centimetres long, is developed from the genital papilla. This papilla is not well developed in non-breeding fish. An atypical variety occurs, in these the body colour is piebald black and white with varying amounts of orange on head and body; these fish are generally females.

Generally a "bump" in profile over the eye. *Scales*: Moderately large, lateral line series 29–32, 4–4½ between lateral line and anterior end of dorsal fin, 16–17 round and seven over top of caudal peduncle, two (rarely three) series on cheek below eye.

T. variabilis (Boulenger).

Young *T. variabilis* (5 cm.). "*Tilapia* mark" not well defined. *Colour*: Fawn or grey with 8–10 vertical stripes; orange tips to dorsal fins. Scales large; eyes large; profile "bump" over eye.

(*c*) *Colour*: Fawn or grey; lips uniform with body colour; dorsal fin tips fawn, grey, or if red, deep crimson (never orange). Breeding males develop black ventral surface and red on sides of body, pelvic and anal fins black; no genital tassel is developed. Iris light greenish yellow, pupil smaller than in 9 (*b*) above. Genital papillæ of non-breeding fish poorly developed. Profile without "bump" over eye. *Scales*: Small, 32–34 in lateral line series, five between lateral line and anterior end of dorsal fin, 18–20 around and 8–9 over top of caudal peduncle, three (rarely two) series on cheek below eye.

T. esculenta (Graham).

Young *T. esculenta* (5 cm.). "*Tilapia* mark" round, black and well defined, extending from last dorsal spine to third soft ray and surrounded by a clear area. *Scales*: Smaller and less distinct than in *T. variabilis*. *Colour*: Fawn or grey without vertical stripes and without orange tips to dorsal fin; eye smaller than in *T. variabilis* and profile straighter.

NOTES ON THE PRESENT GEOGRAPHICAL DISTRIBUTION

T. melanopleura is widely distributed in Africa and occurs in South Africa, Lake Nyasa, the Belgian Congo, and in West Africa, but in East Africa it is only indigenous to Lake Tanganyika. *T. melanopleura* is used in ponds in the Congo, and has been introduced into ponds and dams in Kenya and Tanganyika, where it is now fairly widely distributed. In 1954 a few *T. melanopleura* escaped into the Kenya waters of Lake Victoria.

Although grown in South Africa and Southern Rhodesia, this species does not thrive if the water is too cold [5 and 10].

In the Congo *T. melanopleura* is considered a useful species for clearing weeds from ponds [4] but in ponds in Kenya results with this species have not been impressive [3].

T. zillii is widely distributed and occurs in Palestine, the River Nile and in West Africa. In East Africa *T. zillii* is indigenous to Lake Albert only.

In April, 1951, *T. zillii* from Lake Albert were introduced into dams in Teso, Uganda. From Kidetok Dam, Teso, this species was taken to dams in Ankole, Uganda, in April, 1953, and to Nyanza Provincial Fishponds, Kisumu, in December, 1953. From Kisumu it was introduced into other dams in Kenya and many thousands were put into the Kavirondo Gulf in 1954. According to the Game Department, Entebbe, a few *T. zillii* may have escaped from the Kijansi ponds near Entebbe into Lake Victoria, during 1954.

T. zillii is a good table fish and is useful for controlling weeds in dams as it feeds largely on aquatic vegetation. In West Africa it has been noted that this species eats mosquito larvæ [9]. In the Teso dams *T. zillii* grew well, fish weighing 1 lb. 11 oz. being caught two years after stocking with fry 2–10 cm. long. In ponds this species may, however, runt and *T. zillii* in overcrowded ponds have been found breeding when only 7 cm. long.

As *T. zillii* occurs in Palestine, it must be able to withstand low temperatures and considerable changes in temperature.

Lake Albert and River Nile Species

T. zillii has already been mentioned. Other species of this geographical group are *T. nilotica, T. galilæa* and *T. leucosticta*; these feed on algæ and are mouth brooders. Only *T. nilotica* and *T. leucosticta* occur in Lakes George and Edward, and *T. nilotica* is the basis of the large fishery on Lake George. *T. nilotica* and *T. galilæa* occur in Lake Rudolf.

T. nilotica has been introduced into many lakes in Uganda, e.g. Lake Bunyoni, Lake Mutanda and other waters in Kigezi, the Koki Lakes (Kijanebalola, Changwora, Kachira) and Lake Nakivali. In each of these lakes this species now forms the basis of a flourishing fishing industry. This species was introduced into Teso dams in April, 1951. *T. nilotica* is a very plastic species, and on the whole it grows well in dams and does not appear to breed so freely or runt as badly as some other species. The species referred to as *T. nilotica* from the Pangani River [6] and distributed around Korogwe, Tanganyika, under this name, is now considered to be a new species [11] and not *T. nilotica*.

T. leucosticta was introduced into the Teso dams in April, 1951, where it has grown well; fish of 1¼ lb. being caught two years after stocking. From Kidetok Dam, Teso, this species was taken to the Nyanza Provincial Fishponds near Kisumu in December, 1953. Here, and in fishponds near Entebbe, *T. leucosticta* is breeding when only 7 cm. long. Some may have escaped into Lake Victoria in 1954.

T. galilæa—St. Peter's fish from Palestine. This species was introduced from Lake Albert into the Teso dams in April, 1951, but apparently did not survive. The very fine pharyngeal teeth of *T. galilæa* suggest that it is a phytoplankton feeder and thus is not likely to do well in dams.

Species of the Lake Victoria System

The Lake Victoria species, *T. esculenta* and *T. variabilis* are both plankton eaters and mouth brooders. They occur naturally in Lakes Victoria and Kyoga only, but are now very widely distributed in dams in Uganda and parts of Kenya and Tanganyika within the Lake Victoria drainage basin. Fry from brooding females of both species were taken to the fish farm at Korogwe in June, 1950, and were breeding there at 16–19 cm. long six months later.

Tilapia esculenta is a plankton feeder and does not grow well in dams, rarely exceeding 20 cm., on the other hand *T. variabilis* may do well in dams. For example, in Lessos Dam *T. variabilis* weighing 1 lb. 7 oz. were caught three years after stocking.

In Lake Victoria *T. esculenta* occurs in the sheltered gulfs where the bottom consists of algaceous mud; this is the species exported in large numbers from the Kavirondo Gulf to Nairobi. *T. variabilis* is found along exposed shores in Lake Victoria and is the species caught by anglers above the Ripon Falls and in the River Nile.

Tilapias of the Eastward Flowing Rivers

Tilapia mossambica and *T. nigra* are both mouth brooders, and in both species the male grows larger than the female and often develops an elongated snout and concave upper profile.

T. mossambica forms the basis of the extensive *Tilapia* culture in the Far East where it was introduced some time before 1939. This species has now been moved to many parts of the world, e.g. the West Indies and Hawaii. It is a native of the Eastward flowing rivers of Africa from Kenya to Natal; it has been found some distance out to sea off Kenya and will grow in brackish water, but it is not found far up the rivers (Copley, *in lit.*). It has not been used in ponds and dams in East Africa except in brackish ponds on the Coast, although a new sub-species was found in some of the Korogwe ponds and had evidently gained access from the water supply from the Pangani River [11].

T. nigra is a native of the Athi River and has been introduced into dams in Kenya. The behaviour of this species in ponds has been investigated by Brown and van Someren, who found that the males grow faster than the females, thus this species lends itself to monosex culture [2 and 3].

Central African Species

T. macrochir is a species of considerable commercial importance in Lakes Bangweulu and Mweru, and has been used in ponds in the Congo. A few fish of this species were introduced into the ponds at Korogwe on the Pangani River towards the end of 1950.

Other East Afrcian Species

Other species indigenous to East Africa, which have not been tried in ponds or dams, include *T. karomo* Poll from the Malagarasi Swamps, and *T. rukwænsis* Hilgendorf and Pappenheim, from Lake Rukwa. Three other new species and one new sub-species from Lake Jipe and the Pangani River, described by Lowe [11], have all been grown in fishponds.

CONCLUSION

There are more than a dozen species of *Tilapia* in dams and ponds in various parts of East Africa. The culture of these fish is still carried out rather empirically; until more is known of the behaviour of the different species it is highly advisable that new dams should only be stocked with species already in the drainage area. A possible exception to this recommendation might, however, be made in favour of the easily recognizable weed-eating species *T. zillii* and *T. melanopleura*. In all cases when new dams or ponds are stocked records should be kept of the origin of the *Tilapia* used.

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A STUDY OF CROP PRODUCTION IN RELATION TO RAINFALL RELIABILITY

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One of the major hazards facing the development of agriculture in marginal lands is the irregularly distributed rainfall. The Overseas Food Corporation began large-scale mechanized agriculture in the Southern Province of Tanganyika in 1948, and in the actual area of operations the rainfall records are inadequate to assess the reliability of rainfall by the method of Glover and Robinson [1].

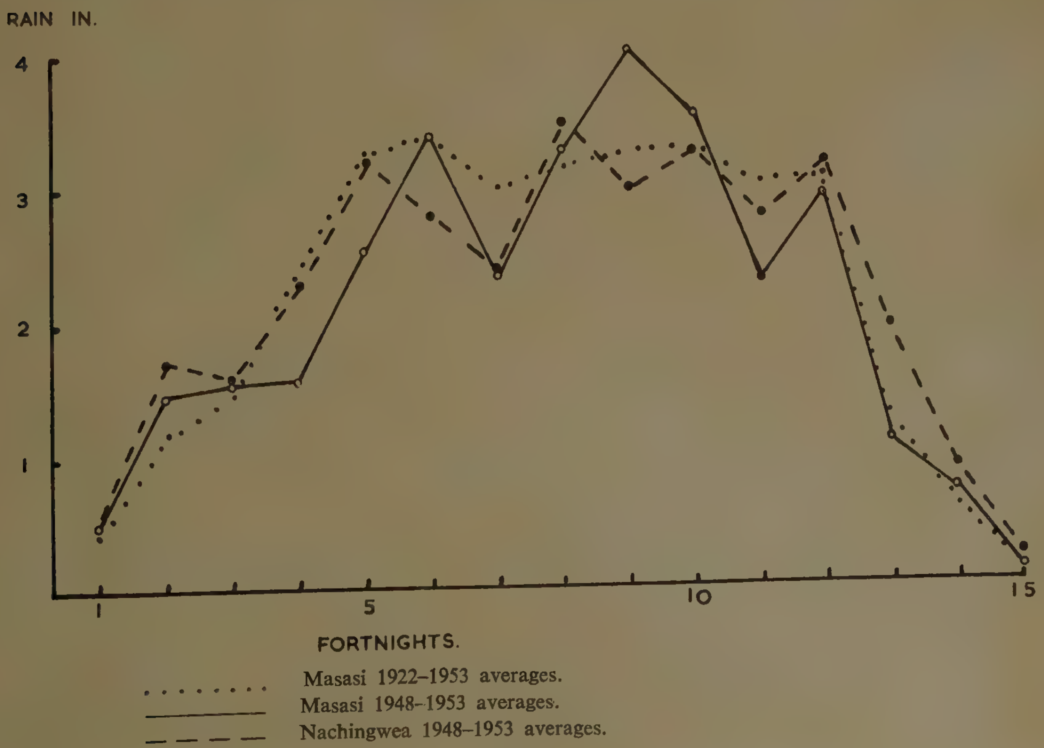
Rainfall has been recorded since November, 1921, at Masasi, 23 miles south of Nachingwea. The mean fortnightly totals of rainfall for both stations from 1st November to 29th May for six seasons is shown in Fig. 1. The rains begin and end at the same times, the seasonal trends are very similar, and the mean seasonal totals, Masasi 33.5 and Nachingwea 31.7, showed no significant difference. Thus the rainfall at each station can be regarded as a sample from the same distribution, and the long-term records from Masasi can be used to assess the reliability of rainfall at Nachingwea, by the method referred to above.

Rainfall Characteristics

Seasonal totals (i.e. from 1st November to 29th May) vary considerably, from 20.6 to 45.4 in., mean 32.77. The chances of more than a certain amount of rain falling, expressed as percentage of seasons, is given below.

Rainfall more than	Percentage Probability	
	Calculated	Recorded
40	17	25
35	39	41
30	64	60
25	84	78
20	94	100

Fig. 1—Mean seasonal distributions of rainfall at Nachingwea and Masasi, fortnightly totals from 1st November to 29th May

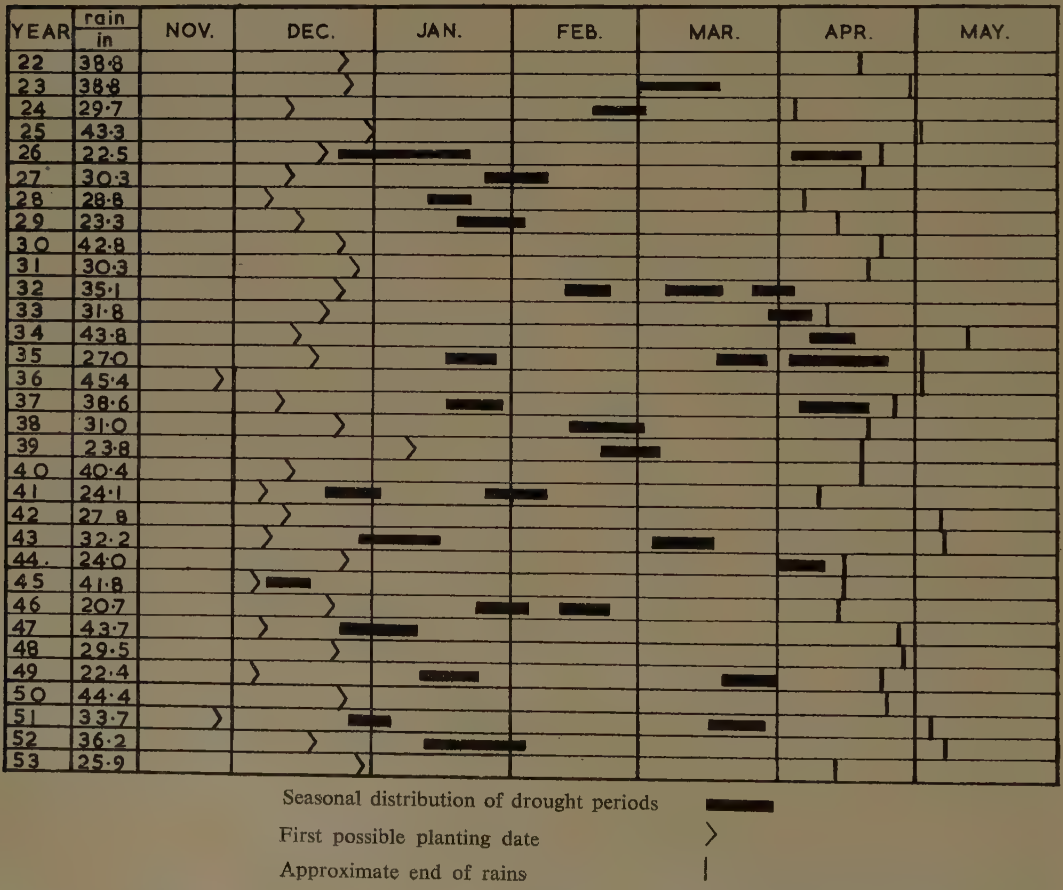


The correspondence between the percentages calculated and recorded is close, considering that only 32 seasonal totals are available. Only in rather more than 50 per cent of seasons can more than 30 in. of rain be expected to fall between 1st November and 29th May. Part of the rainfall, i.e. that which falls before 1st December and after 15th April, is not available for annual crops. This point will be referred to later in regard to specific crops, but emphasizes the marginal nature of the rainfall in an area where evaporation rates are high.

A considerable amount of the rain falls in heavy showers and storms of more than one inch in a day. Daily rainfalls of over two inches are not common, and of over four inches are rare; only five days in 32 years with over four inches have been recorded. Approximately 45 per cent (range 40–50 per cent) of the annual rainfall falls in heavy showers and storms of more than one inch per day. As would be expected, there is a very close correlation between the total seasonal rainfall and both the amount falling in heavy showers and storms of more than one inch in a day, and the amount falling in showers of less than one inch in a day. But since such a high proportion of the rain falls in heavy showers and storms, it is of the greatest importance in developing a system of agriculture in areas of marginal rainfall to ensure that such rains are held where they fall and not allowed to run away down conservation ditches or cause damaging sheet erosion on the fields.

The occurrence of droughts of varying degrees of severity is an important factor in crop production locally. The distribution of drought periods of 10 days or more without rain, or in the case of longer periods including light showers of no importance, is shown in Fig. 2. It appears that such droughts are likely to occur at any time during a growing period, and that there is no typical "break" in the rains

Fig. 2



when the N.E. monsoon changes to the S.E. monsoon. The number of droughts in a season varies from none to three with the following distribution:—

No. of droughts per year	No. of years
0	10
1	13
2	7
3	2

There is no association between the number of "drought days" and the total rainfall falling after the first possible date of planting.

Rainfall	Mean No. of drought days
more than 23 in. (*Good*)	11
19–23 in. (*Poor*)	20
14–19 in. (*Bad*)	15

The rains usually begin in November but are not sufficient in quantity for planting until December. Planting of the long season crops, maize and groundnuts, usually begins in late December as a result of local experience over a few seasons. It was, therefore, of interest to examine the Masasi records to see whether such a time is justified or whether a conservative attitude is being adopted. The average first possible planting date (i.e. after about 2 in. of rain had fallen in a few days) was found to be 19th December, and in 66 per cent of years planting could begin between 9th and 29th December, suggesting that a conservative attitude has been adopted. The rains tend to finish between 10th April and 3rd May, giving an average period of 124 days in which rain can be expected to fall once planting can begin.

Rainfall and Crop Production

A study of the relationship between rainfall and crop yields, where reasonably accurate estimations are available near to rain gauges, shows that good yields of groundnuts, 800 lb. of kernels per acre, and of maize, 2,000 lb. of grain per acre, can be grown on 23 in. and 21 in. of rainfall, providing that this amount falls within 120 days and 100 days respectively of planting. The rainfall must be reasonably well distributed. Groundnuts can be regarded as fairly resistant and maize rather less so to drought periods of even 21 days. In 1951, a 21-day drought period after 2.3 in. had fallen in four consecutive days occurred. Groundnut plants, var. Mwitunde, were only seven days' old when this drought began, but yielded 950 lb. of kernels per acre even though rosette disease was present. In 1954 a dry period occurred in which 0.75 in. fell in 28 days when groundnuts, var. Mwitunde, were 64 days' old, and maize, var. Katambili, 57 days' old, but yields of 1,700 lb. kernels and 2,000 lb. of grain were obtained.

Robinson and Glover [2] have developed a method of assessing the reliability of a distribution of rainfall in a growing period. However, in view of the resistance to drought mentioned above, and the rarity of drought periods of over 21 days, an estimation of the reliability of the total amount required to produce good yields is sufficient to assess the frequency with which good, poor, or bad yields can be expected. The frequencies with which such seasons can be expected for groundnuts and maize are give below:—

Groundnuts

Seasonal Rainfall Required	Percentage Expectation	
	Date of Planting	
	Dec. 15	Dec. 29
More than 23 in. (*Good*)	75	64
19–23 in. (*Poor*)	15	18
Less than 19 in. (*Bad*)	10	18

Maize

Seasonal Rainfall Required	Percentage Expectation		
	Date of Planting		
	Dec. 29	Jan. 12	Jan. 26
More than 21 in. (*Good*)	57	57	44
18–21 in. (*Poor*)	17	17	28
Less than 18 in. (*Bad*)	26	26	28

For groundnuts the advantage of planting earier than 29th December, when soil conditions permit, is clear; the chances of obtaining good crops is increased and that of getting poor crops reduced. Maize planting before 22nd December is likely to be hazardous from the point of view of harvesting conditions, since the crop will be mature when an average of just over three inches of rain per fortnight can be expected for at least two fortnights. Maize planted after 29th December will be ready for harvest when only an average of 1.25 in. can be expected in the next fortnight. The chances of growing good crops of maize do not appear to be as high as those for groundnuts. Since the average rainfall per fortnight is just over three inches during the period 20th December–6th April, (Fig. 1), i.e. eight fortnights, and the maize variety in production, Katambili, requires seven fortnights for its growth, adjustments in planting dates cannot increase the average amount falling on the crop during its growth period. Increased chances of growing good crops will have to be sought by other means, such as selecting a strain with a longer growth period, higher yielding strains, and the prevention of run-off from heavy showers and storms by tie-ridging.

The planting season for sorghum begins in early February, and seasonal totals from 10th February to 4th May average 17.1 in. Data on the relationship between rainfall and good yields (1,800 lb. per acre of Dobbs, a tall growing variety) is scanty but suggests that 17 in. and over should give good yields. Thus only in 50 per cent of seasons could good crops be expected for plantings after 10th February. Even if a lower requirement of 15 in. is accepted, then only in 63 per cent of seasons will more than this amount fall. The percentages of good, poor and bad seasons likely are shown below:—

Planting on 10th February

Seasonal Rainfall Required	Percentage Expectation
More than 17 in. (*Good*)	50
12–17 in. (*Poor*)	29
Less than 12 in. (*Bad*)	21
More than 15 in. (*Good*)	63
12–15 in. (*Poor*)	16
Less than 12 in. (*Bad*)	21

It would appear that an appreciably earlier date than 10th February would be advantageous for planting. The likely increases in successful seasons for earlier plantings are shown below:—

Seasonal Rainfall Required	Percentage Expectation	
	Date of Planting	
	Jan 28	Feb. 3
More than 17 in. (*Good*)	82	67
12–17 in. (*Poor*)	11	21
Less than 12 in. (*Bad*)	7	12
More than 15 in. (*Good*)	89	77
12–15 in. (*Poor*)	4	11
Less than 12 in. (*Bad*)	7	12

Plantings between 28th January and 3rd February offer good chances of success.

GENERAL

This study emphasizes the great importance of utilizing rainfall to the full in this area. Although the mean total seasonal rainfall is 32.8 in., only that falling in the months December to April can be regarded as available for annual crops, i.e. a mean of 30.4 in. and the variation from year to year is considerable, 19.4–42.0 in. The number of years in which more than a given amount of rain can be expected to fall in this period is given below:—

Seasonal Rainfall (December–April)	Percentage Expectation (Years)
More than 40 in.	9
More than 35 in.	26
More than 30 in.	52
More than 25 in.	67
More than 20 in.	92
More than 15 in.	98

These figures illustrate the narrow margin of rainfall on which successful agriculture, African as well as mechanized, depends when only in 67 per cent of seasons can more than 25 in. of rain be expected from 1st December to 4th May, and 23 in. and 21 in. falling in 120 and 100 days are required for good crops of groundnuts and maize respectively.

Few measures can be taken to minimize the adverse effects of low rainfall during the growing season. Very early planting of groundnuts can be risked as even young plants are fairly drought resistant. Sorghum, and probably soyabean, can be planted at a time determined by the rainfall distribution to give reasonably good hopes of success. Early cultivation of land for the later sown crops, and leaving it in a rough state to prevent surface run-off, will also help by preventing water loss through the rank growth of weeds that often springs up.

Probably the most important measure immediately applicable is to prevent surface run-off by tie-ridging in mechanized agriculture and also in African agriculture as recommended by Prentice [3]. Tie-ridging is not, however, the final solution. When soil structure is destroyed by continued cropping the soil becomes impermeable and water stands in the basins, an unduly high proportion is lost by evaporation, and the standing water has adverse effects on many crops. Positive methods must be found to restore the permeability of the soil. Trash farming would not be feasible locally because of pest and disease problems, but green manuring might be useful as in S. Rhodesia. The most valuable method would be to restore permeability during the resting phase of the rotation. A solution of the problem along these lines is urgently required, perhaps by utilizing grass or legumes that have a massive root system. Improved permeability would be particularly valuable in seasons of high rainfall, permitting rapid absorption of the rain and reducing damage by surface wash.

I am indebted to Dr. H. C. Pereira of E.A.A.F.R.O. for useful advice.

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[1] Glover, J., and Robinson, P. *E. Afr. agric. J.*, *19*, p. 11.

[2] Robinson, P., and Glover, J. *E. Afr. agric. J.*, *19*, p. 137.

[3] Prentice, A. N. *E. Afr. agric. J.*, *12*, p. 101.

REVIEW

A Critical Review of the World Literature on the Lepidopterous Stalk Borers of Tropical Graminaceous Crops, by W. F. Jepson, O.B.E., Ph.D. Commonwealth Institute of Entomology, 41 Queens Gate, London, S.W.7, 1954, pp. vi–127. Price fifteen shillings post free.

This learned work by Dr. Jepson, formerly an economic entomologist in the tropics and now a well-known teacher of entomology, contains a carefully sifted mass of information from the literature, together with his usually sound but sometimes provocative comments. It can be exepected from its title that every economic entomologist will obtain, study, and frequently consult it, to his great advantage. And it can unhesitatingly be thoroughly recommended to all serious students. By its very nature it cannot be recommended to anyone in search of light reading.

The writer makes a very good case for his conviction that the problem of stem-boring insects in rice, maize, the millets and sugarcane, is chronic, serious and often discouraging. After a short historical section, he deals with the complicated and still uncompleted work on the systematics of the moths concerned. This is followed by a section on their bionomics; others on population estimation and damage assessment; the relation of cultural practices to stalk borer damage; and on parasites, predators and disease of stalk borers. A final section deals with all forms of control, and includes conclusions and recommendations for future research. There is a ten-page list of references and an index to names of insects and plants.

In a review for East African readers it must be remarked that the reference to the control of Busseola (the Maize Stalk Borer) in Kenya is inadequate and this is perhaps because Kenya entomologists have not published sufficient on the subject. The statement that the dust used is 2½ per cent DDT must be corrected, since only a 1 per cent DDT dust has been used in Kenya from the inception of this effective method of control. This is not only recommended, but has become the standard control in the areas of infestation. That it continues to be generally used by hard-headed farmers is an indication of its efficacy. Different methods of applying DDT by low-volume sprayers and aircraft are now being tried. The object of legislative restriction of planting dates as used in Kenya is not brought out. It is to ensure a maize-free period before the next planting to reduce the carry-over of moths from one planting to the other. It is safe to say that maize growing would be uneconomic in the worst infested areas without the restriction of planting dates and the use of DDT, but with the use of these methods good control is usually obtained.

The publication is printed in the usual high standard of the Commonwealth Institute of Entomology, and will remain an essential contribution for the study of this important economic field.

R. Le P.

PLANT ECOLOGY AS AN AID TO COLONIAL DEVELOPMENT

A recent article in *Colonial Plant and Animal Products* by D. R. Grantham and R. D. Pilson Volume IV, Number 2, 1954, pages 110–136 under the above title describes work done by the Overseas Food Corporation in Tanganyika. The failures of the "Groundnut Scheme" have been much publicized but their solid achievements are less recognized. The article deals with a method for assessing the agricultural value of tracts of bush country with the aid of aerial photography. Its aim is to show that a study of the vegetation, the outlines of which may be traced from photographs, gives a reliable assessment of the soil types at any rate for a first reconnaissance over large areas.

The work described was done in the Southern Province around Nachingwea where over 1,000 square miles was studied and mapped. Coloured soil and geological maps are to be published in a Bulletin of the Tanganyika Geological Survey entitled *The Geology and Ecology of the Nachingwea Region.*

The first impression of this country suggested that there were large areas of relatively uniform soil but the reconnaissance differentiated and mapped some 20 types of soils and of vegetation, which shows the necessity for extensive preliminary examination before any major scheme is launched. Having given information on the climate, physiography and geology of the area, the article outlines soil formation history and the distinction between deep mantle and residual deposits on which the relatively shallow soils are formed. Soil catenas exist, but in those parts with a diversified geology their normal sequence is interrupted; an intimate connexion between soils and geology is postulated and a still closer connexion between soils and vegetation.

The present vegetation has for the most part a complicated history due to clearing for native cultivation and regeneration under varying conditions. A hypothesis for this history is given.

Four pages of vegetation tables give the principal species which occur on each soil type. The authors do not claim that these lists are either complete or entirely reliable in detail but they nevertheless give a sound background for the principles by which such work may be extended over similar areas in the future.

The method used was to traverse the bush at one-mile intervals using compass, measuring wheel and aneroid barometer, and recording topography, soils and vegetation; tree counts were made at intervals. A plotting of the traverse was located on the aerial photographs and the vegetation patterns seen in the latter were interpreted from the field notes; the patterns thus interpreted in terms of vegetation and soils were re-drawn into maps and a topographic map also drawn. These maps were only of "reconnaissance" standard but were sufficiently informative to give acreages of the different soils and to formulate the general layout for roads and installations.

The eastern, drier side of Africa is eminently suitable for this type of investigation; in the western, wetter parts the correspondence between vegetation and soils is less marked or absent because of the extensive leaching and lateritization of soils in high rainfall areas.

The article as published is largely factual but Dr. Grantham's personal opinion, not included in the article, is that had the groundnut scheme started with at least five years' mapping, experimentation and the provision of communications and facilities under Government auspices, followed by the offer of farms to private enterprise, possibly aided by interest-free loans for short periods, similar to the Land Bank loans, the scheme might well have been a success and opened the way to extensive development of large tracts of land which now lie idle. Under native shifting cultivation only about one-tenth of the land is in use at any one time (up to seven years' cultivation and up to 70 years' bush fallow). Under European agriculture the land is continuously used, subject to crop rotation, perhaps an eightfold increase in productivity, without detriment to the number of Africans working on the land, and while they work, they learn.

LIVING VIRUS VACCINE IN RABIES CONTROL

(*From Chronicle of the World Health Organization*, (1954), *8*, 263–266)

A campaign of mass vaccination of dogs, carried out in Israel with the aid of W.H.O., has shown that live antirabies vaccine—still in an experimental stage a few years ago—may become a decisive weapon in rabies control.

The "Flury" strain of the rabies virus which is the principal strain used in preparing the vaccine, was isolated from central-nervous-system tissue of a girl named Flury who died of untreated rabies in 1939. This virus, maintained through passages on the chick brain, has, since 1945, been adapted to the developing chick embryo. Continued egg passage has resulted in a lessened pathogenicity for experimental animals without apparent loss of antigenicity. Vaccine at the 40th to 50th egg-passage-level is now used for the immunization of dogs; for the vaccination of cattle, particularly of herds in South America which are threatened by the bites of rabid vampire bats, vaccine at the 170th to 180th passage is used. The "Kelev" strain, at the 60th to 70th passage, is also employed as vaccine for dogs.

Laboratory studies and limited field trials since 1950 had shown the harmlessness, when injected intramuscularly, and the strong immunizing power of Flury-strain vaccine for dogs. This vaccine seemed to confer an immunity of three years or more, displaying its superiortiy in this respect over inactivated nervous-tissue vaccines, particularly phenolized vaccines. However, the efficacy of the vaccine had not yet been proven under field conditions on a nation-wide scale. W.H.O., therefore, decided to sponsor an antirabies pilot project in an area of limited size where rabies was enzootic. In this campaign, compulsory vaccination of dogs with living modified virus vaccine prepared in chicken embryos was to complement the usual control measure—registration and supervision of dogs, elimination of stray dogs, wildlife control, etc.

The Republic of Israel was chosen as the demonstration area. Rabies is enzootic in Israel: from 1932 to 1950, the annual number of cases of rabies in animals varied between 50 and 333. In 1949, there were 138 laboratory-confirmed cases (80 in dogs, 27 in ruminants, 20 in jackals, seven in horses, and four in cats); and rabies had become a serious health problem. Another reason for selecting Israel for the demonstration was that the veterinary and public health services of the country were well organized, adequately staffed, and able to carry out the control measures, which were to be under the technical guidance of W.H.O.

Two types of living modified virus vaccine, of either the Flury or the Kelev strain, prepared in the chicken embryo were used in this campaign. The first was a Flury-strain vaccine which was produced and freeze-dried in New York and shipped to Israel by air in cartons containing dry ice. Upon arrival in Israel, the vaccine was placed under refrigeration (+ 4° to + 8° C). It was subsequently taken in thermos flasks packed in ice to the field of operations and used within one to two hours after restoration with diluent. The vaccine, when restored with 3 ml. of distilled water, contained a 33⅓ per cent suspension of infected whole chicken-embryo. Approximately 26,000 doses of this vaccine were supplied to the health services of Israel. The second type of vaccine consisted of 2,000 doses of Flury strain and 2,000 doses of Kelev strain prepared by the Virus Laboratory of the State Veterinary Service, Haifa.

Municipal and State veterinarians and their assistants carried out the vaccination and registration of dogs, which was preceded by an intensive publicity campaign. The dogs received 3 ml. of the vaccine, injected intramuscularly into the posterior fleshy muscles of the thigh. At the beginning of 1952, it was estimated that almost 90 per cent of all dogs of six months or over—more than 15,000 dogs—had been vaccinated. Other control measures were also applied. In towns, stray dogs were destroyed in gas chambers; in rural areas, they were shot. The carcasses of donkeys into which strychnine was introduced were used as bait in jackal-reducing programmes. Quarantine stations for the detention and observation of rabies-suspect dogs were established in five localities.

The results of the campaign were immediately apparent. While in 1950 the number of cases of rabies was 44—a figure which, it must be admitted, indicated a natural recession of the disease in comparison with previous years—in 1951 it was 8; in 1952, 10; and in 1953, three. One of two cases of rabies which appeared among the vaccinated dogs may be considered as a vaccination failure.

The problem of rabid jackals, which had been a concern to cattle owners, also seemed practically to disappear. The explanation may be that the elimination of canine rabies removed an essential link in the rabies-transmission cycle of jackals.

It is impossible to evaluate precisely the role that compulsory immunization of dogs with living virus vaccine may have played in the elimination of rabies as a public health problem in Israel. There are various reasons, however, for considering vaccination as the principal factor. Although numerous measures had been satisfactorily applied in the years preceding the campaign, e.g. registration of dogs, reporting of cases of rabies, laboratory diagnosis, elimination of stray animals, and destruction of wildlife reservoirs of the disease—these measures had not sufficed to bring rabies under control. This objective was not attained until the mass vaccination of dogs was introduced.

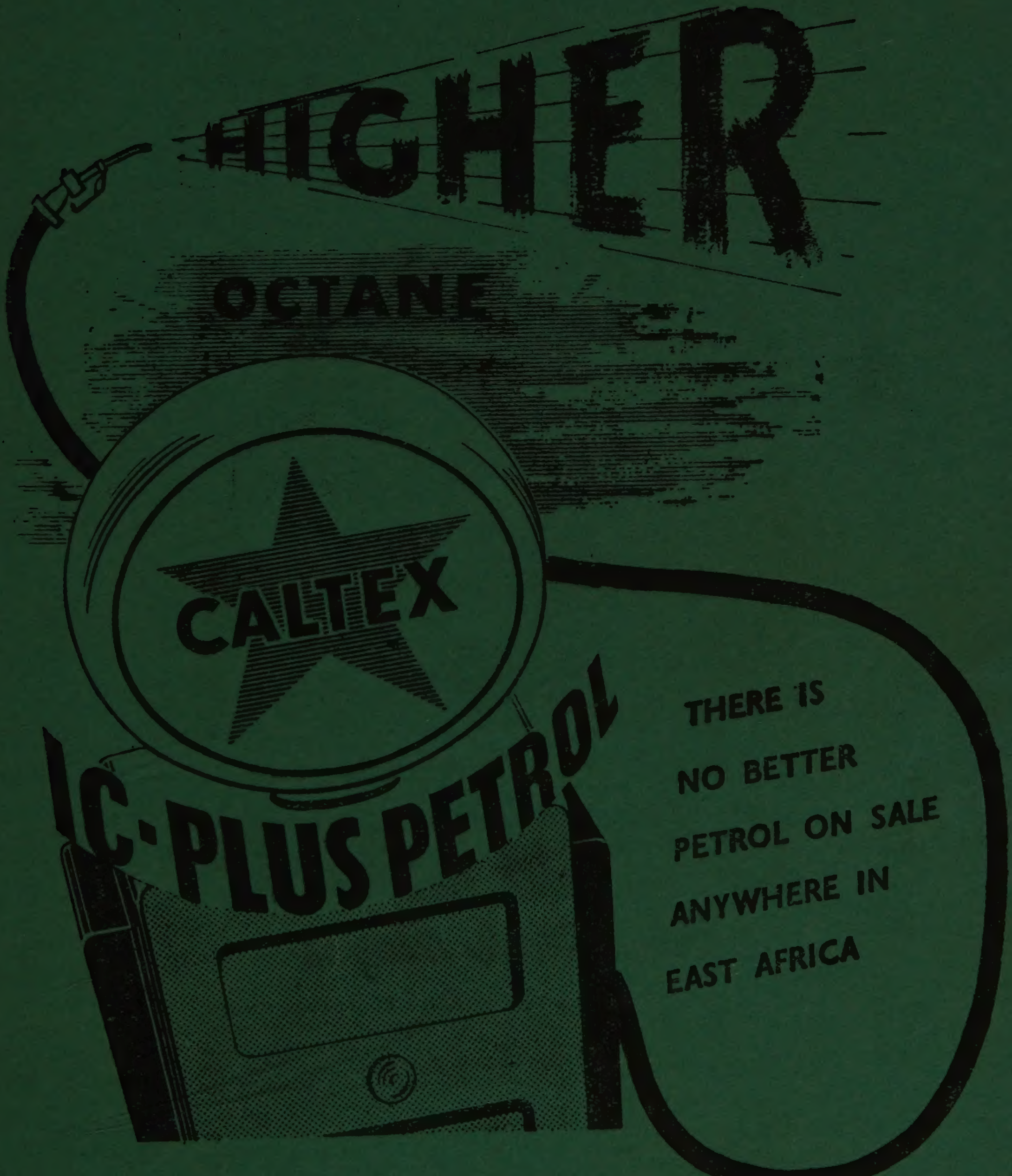
Further evidence of the efficacy of vaccination of dogs is provided by reports from Malaya, where an active antirabies campaign was undertaken also with W.H.O. technical guidance and collaboration. There, compulsory vaccination of dogs, particularly with Flury virus, succeeded in controlling the disease, which, enzootic since 1924, had become an alarming health problem in 1952.

Information has been received recently from Israel of a recrudescence of rabies during the first half of 1954. Thirty-three cases have been reported in animals (30 dogs, two cows, and one horse). One human fatality also occurred.

It is significant that none of the cases in dogs were in vaccinated animals. Because of financial difficulties, the control of stray dogs was relaxed in the latter part of 1953 and the first half of 1954. This explains the increase in the number of cases and emphasizes the necessity of stray-dog control along with vaccination procedures. Steps are being taken by the Israeli Government to resume stray dog control. Of interest is the fact that most of the cases occurred in puppies under six months of age in one district —the suburbs of Haifa. In accordance with recent experimental results, puppies are now being vaccinated at two to three months of age instead of waiting until they are six months old, as was done during the early part of the campaign in Israel.

Inter-African Bureau for Epizootic Diseases, Mugua, P.O. Kikuyu.

Information Leaflet: IBED/Tech.Rep./11/54. (December, 1954.)



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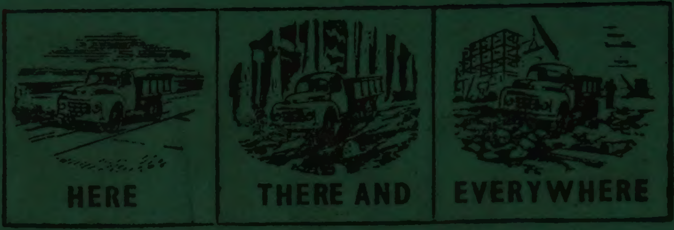

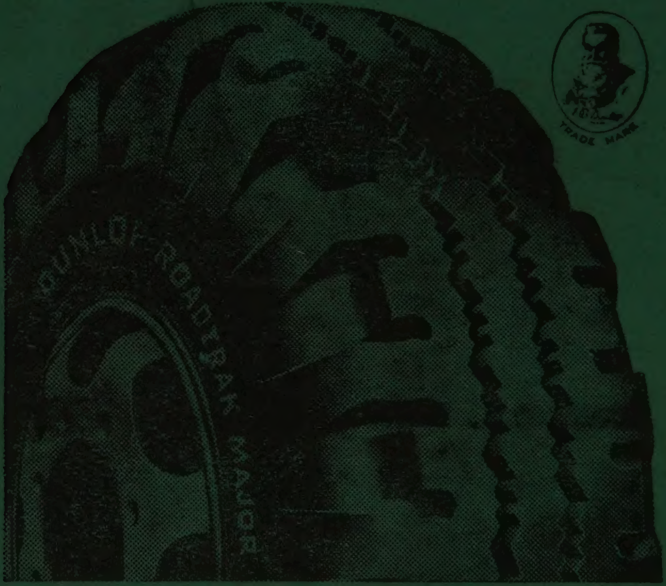

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